

INTERVENTIONS TO MIMIC THE EFFECTS OF CALORIE RESTRICTION

Background of the Invention

Field of the Invention

5 For years, researchers have attempted to identify biomarkers of aging to facilitate the identification of interventions that might slow or reverse the aging process. Dietary calorie restriction (CR) is the only well-documented method for extending life span in homeothermic vertebrates, and is the most effective means known for reducing cancer incidence. Although many of the physiological consequences of CR were
10 described 65 years ago, there is no consensus regarding its mode of action. Consequently, there has been no practical method of identifying interventions that might mimic such calorie-restriction effects. Rather, a researcher would have to wait the test animal's lifetime to determine whether a particular intervention impacted life-span and/or cancer incidence.

Description of the Related Art

15 Mammals seem to share a common set of genes, and yet they have widely differing life spans. It is impossible to know at present whether the differences in life spans are due to differences in the sequence of specific genes, or to differences in their expression. However, it is clear from many years of study in dozens of laboratories that
20 long term reduction in dietary calorie consumption (CR) delays most age-related physiological changes, and extends life span in all species tested, provided malnutrition is avoided (Weindruch, et al. *The Retardation of Aging and Disease by Dietary Restriction* (Charles C. Thomas, Springfield, IL, 1988)). These studies also have shown
25 that CR is the most effective means now known for reducing cancer incidence and increasing the mean age of onset of age-related diseases and tumors in homeothermic vertebrates (Weindruch et al. (1982) *Science* 215: 1415). Thus, it seems clear that life spans can be extended through a relatively simple dietary regimen. However, there are no studies on the effects of short term calorie restriction on metabolism and gene expression.

30 One report has been published of gene expression profiling in muscle (Lee et al. (1999) *Science* 285: 1390) In these studies, many age related changes in muscle gene

expression appeared to be prevented or reversed by CR. The expression profiles of 6500 genes were compared among old, long-term CR and control mice, and young control mice. Some age-related changes in muscle gene expression appeared to be wholly or partially prevented by CR.

Summary of the Invention

The present invention contemplates a method of identifying interventions within a short time frame that mimic the effects of calorie restriction. Such interventions will lead to increased life span, reduce cancer incidence, and/or increase the age of onset of age-related diseases and tumors.

In a preferred embodiment a method of identifying an intervention that mimics the effects of caloric restriction in cells is disclosed, comprising the steps of :

obtaining a biological sample;

exposing said biological sample to an intervention;

waiting a specified period of time;

assessing changes in gene expression levels, levels of RNA, protein, or protein activity levels related to one or more biomarkers of aging; and

identifying said intervention as one that mimics the effects of caloric restriction if one or more changes in said levels also occurs in caloric restriction.

The biological sample may be either in vitro or in vivo. In a preferred embodiment, the biological sample comprises cells. In a more preferred embodiment, the cells are obtained from a mammal. In an even more preferred embodiment, the mammal is a mouse.

In one embodiment, the change in gene expression levels, levels of RNA, protein, or protein activity levels corresponds to a change in gene expression for a gene encoding a chaperone protein. In a preferred embodiment, the chaperone protein is GRP78.

In one embodiment, said biomarker is apoptosis. In another preferred embodiment, said biomarker is aging. In another preferred embodiment, said biomarker of aging is a production of cancer cells.

In a preferred embodiment, the changes in said gene expression level, levels of RNA, protein, or protein activity levels related to one or more biomarkers of aging

occur in 6 weeks or less. In a more preferred embodiment, the changes in said gene expression levels, levels of RNA, protein, or protein activity levels related to one or more biomarkers of aging occur in four weeks or less. In an even more preferred embodiment, the changes in said gene expression levels, levels of RNA, protein, or protein activity levels related to one or more biomarkers of aging occur in two weeks or less. In a most preferred embodiment, the changes in said gene expression levels, levels of RNA, protein, or protein activity levels related to one or more biomarkers of aging occur in about two days or less.

In a one embodiment, changes in gene expression are evaluated using a gene chip. In a preferred embodiment, the gene chip contains genes for immune system activation. In another preferred embodiment, the gene chip contains genes for DNA repair. In another preferred embodiment, the gene chip contains genes associated with apoptosis. In another preferred embodiment, the gene chip contains genes for the enteric nervous system.

In an alternate embodiment, the biological sample is a test animal. In a preferred embodiment the disclosed method additionally comprises determining changes in said levels in a reference animal having identifying characteristics of a long-term calorie-restricted animal wherein the reference animal has been on a calorie restricted diet for less than about 6 weeks and wherein said changes are used in said identifying said intervention as one that mimics the effects of calorie restriction. In a more preferred embodiment, the reference animal has been on a calorie restricted diet for less than about 4 weeks. In an even more preferred embodiment, the reference animal has been on a calorie restricted diet for less than about 2 weeks.

In a preferred embodiment, the test animal is a mouse. In a preferred embodiment, changes in gene expression are assessed in the test animal.

In a more preferred embodiment, the disclosed method further comprises:

obtaining a gene expression profile from a calorie-restricted reference animal;

comparing changes in gene expression for the test animal to the gene expression profile of the calorie-restricted reference animal; and

identifying said intervention as one that mimics the effects of calorie restriction if the gene expression profile of the test animal is statistically similar to the gene expression profile of the calorie restricted animal.

5 In a more preferred embodiment, the gene expression profile of the test animal is determined to be statistically similar to the gene expression of the calorie restricted animal by one-way ANOVA followed by Fisher's test ($P < 0.05$).

10 In another aspect of the invention, a system is disclosed for identifying an intervention that mimics the effects of calorie restriction in a test animal comprising a test animal and a gene chip comprising genes known to have altered expression during calorie restriction. In a preferred embodiment, the gene chip comprises genes selected from the group consisting of genes for immune system activation, genes for DNA repair, genes associated with apoptosis and genes for the enteric nervous system.

15 For purposes of summarizing the invention and the advantages achieved over the prior art, certain objects and advantages of the invention have been described above. Of course, it is to be understood that not necessarily all such objects or advantages may be achieved in accordance with any particular embodiment of the invention. Thus, for example, those skilled in the art will recognize that the invention may be embodied or
20 carried out in a manner that achieves or optimizes one advantage or group of advantages as taught herein without necessarily achieving other objects or advantages as may be taught or suggested herein.

Further aspects, features and advantages of this invention will become apparent from the detailed description of the preferred embodiments which follow.

25 Brief Description of the Drawings

The file of this patent contains at least one drawing executed in color. Copies of this patent with color drawing(s) will be provided by the Patent and Trademark Office upon request and payment of the necessary fee.

30 These and other feature of this invention will now be described with reference to the drawings of preferred embodiments which are intended to illustrate and not to limit the invention.

FIG. 1. Effects of feeding on hepatic GRP78 and ERp72 mRNA. At 0, 1.5, 5 and 12 h following feeding, 5 mice from each dietary group were killed. Their weights after 24 h of fasting were 22.96 ± 1.49 for CR and 37.12 ± 1.19 g for control mice. GRP78 mRNA (A) and ERp72 mRNA (B) from control (closed circle) and CR (open circle) mice were quantified using dot-blot. RNA loading and transfer were normalized using data obtained from serial probings for 18S ribosomal RNA and S-II mRNA. Similar results were obtained with both control probes. CR and control mice, fed once daily for 30 days, were fasted for 24 hours and killed (n=5, 0 time point) or refed and killed at the times specified (n=5 for each time point). + represents $P < 0.01$ significance of difference between CR and control at each time point. * represents $P < 0.01$ significance of difference from the 0 time point within each dietary group. The 0 and 24 hour times points are the same data set.

FIG. 2. The gene and tissue specificity of the chaperone feeding response. A, The domain of chaperone genes responsive to feeding was determined by quantifying hepatic chaperone mRNA abundance using RNA from mice fasted for 48 hours (n=6; open bars) or from mice fasted 48 hours, refed and killed 1.5 h later (n=6; filled bars). The mRNAs were quantified by dot-blotting and Northern blotting. There was no significant difference in the results obtained with either technique. The dot-blotting results are shown. B, Liver, kidney, and muscle GRP78 mRNA from 24-hour fasted mice (n=4), and from 24-hour fasted mice 1.5 hours after feeding (n=5). These data were from different mice than used in panel A. The statistical significance of the results are indicated (*, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$).

FIG. 3. Effects of CR on hepatic pre-mRNA and GRP78 mRNA abundance. A, RNase protection of pre-mRNA and mRNA in CR and control mice. Hepatic RNA was purified from control and CR mice and hybridized with an RNA probe for transcripts spanning the third intron and fourth exon boundary of the GRP78 gene. The precursor mRNA protected a 223 base region of the probe, labeled GRP78 pre-mRNA, while the GRP78 mRNA protected a 113 base fragment, so labeled in the figure. A probe for S-II mRNA coding sequences was included in each reaction as an internal control. It protected a 185 base fragment labeled S-II mRNA in the figure. Lane 1 shows the protected fragments produced by the GRP78 probe and mouse liver RNA. Lane 2

shows the fragments produced by the S-II probe hybridized to yeast total RNA. Lane 3 shows the results produced by the S-II probe hybridized to mouse liver RNA. Lanes 4, 6, and 8 show the results produced by hepatic RNA from control mice. Lanes 5, 7, and 9 show the results with RNA from CR mice. Quantification of the abundance of the protected fragments representing the GRP78 mRNA (B) and pre-mRNA (C). Studies such as those shown above were conducted using hepatic RNA from 6 CR and 6 control mice. The intensity of the protected fragments was quantified with a phosphorimager. The intensities of the pre-mRNA and mRNA fragments were normalized to the intensity of the protected fragment representing S-II mRNA. Statistical significance is indicated as in the legend to Fig. 2.

Fig. 4. Effects of feeding on hepatic GRP78 mRNA and pre-mRNA abundance. A, RNase protection of probes for hepatic GRP78 pre-mRNA and mRNA in mice after 48 hours of fasting (n=5), or 1.5 h after feeding of 48-hour fasted mice (n=5). RNA purified from liver was hybridized either to a probe for primary transcripts containing the exon 7 and intron 7 boundary of the GRP78 gene which produced a 257 base protected fragment (labeled S-II + GRP78; lanes 7-12), or to a probe for primary transcripts spanning the exon 7 and intron 7 boundary, which protected a 200 nucleotide fragment (labeled S-II + tGRP78, lanes 13-18), as indicated in the figure. GRP78 mRNA produced a 143 nucleotide fragment representing GRP78 mRNA, as indicated in the figure. A probe for S-II mRNA coding sequences was included in each reaction as an internal control. With this probe, S-II mRNA protected a 277 nucleotide fragment, labeled S-II mRNA in the figure. Lane 1, RNA markers. Lanes 2-6, hybridization of the indicated probes with yeast tRNA. Lanes 7-12, hybridization of the GRP78 and S-II probes with RNA from fasted (lanes 7-9) and refed (lanes 10-12) mice. Lanes 13-18, hybridization of tGRP78 and S-II probes with RNA from fasted (lanes 13-15) and refed (lanes 16-18) mice. Quantification of the abundance of the protected fragments representing the GRP78 mRNA (B) and pre-mRNA (C). Studies such as those shown above were conducted using hepatic RNA from 6 CR and 6 control mice. The intensity of the protected fragments was quantified and normalized as described in Fig. 3 above. Statistical significance is indicated as in the legend to Fig. 2.

FIG. 5. Effects of protein synthesis inhibitors on the feeding response of GRP78 (A) and PEPCK (B) mRNA. Mice fasted for 48 h were injected i.p. with vehicle and after 1 hour injected a second time i.p. with vehicle (Refed+Sham; n=6). Mice fasted for 48 hours were injected i.p. with vehicle 30 min before and 30 min after feeding (Refed+Sham, n=6). Mice fasted for 48 h were injected i.p. with cycloheximide and after 1 hour injected a second time i.p. with cycloheximide (Fasted+Cycloheximide; n=6). Mice fasted for 48 h were injected i.p. with cycloheximide 30 min before and 30 min after feeding (Refed+Cycloheximide; n=6). Mice fasted for 48 h were injected i.p. with puromycin and after 1 hour injected a second time i.p. with puromycin (Fasted+Puromycin; n=6). Mice fasted for 48 h were injected i.p. with puromycin 30 min before and 30 min after feeding (Refed+Puromycin; n=6). GRP78 and PEPCK mRNA abundance were determined using purified hepatic RNA. Bars without common superscripts are significantly different ($P<0.005$).

FIG. 6. Regulation of the fasting-feeding response by insulin, dibutyryl-cAMP, glucagon, and ingestion of mineral oil and cellulose. A, Groups of six mice were fasted for 48 h and treated as follows: Fasted+Sham mice were injected with vehicle and 1 h later vehicle injected a second time; Fed+Sham mice were sham injected with vehicle 30 min before and 30 min after feeding; Fed+cAMP mice were injected with dibutyryl-cAMP and theophylline 30 min before and 30 min after feeding; Fed+glucagon mice were injected with glucagon 30 min before and 30 min after feeding; Fasted Diabetic+Sham mice, previously rendered diabetic with STZ, were vehicle injected and 1 h later vehicle injected a second time; Fed Diabetic+Sham, STZ-diabetic mice were sham injected with vehicle 30 min before and 30 min after feeding; Fed Diabetic+cAMP, diabetic mice were injected with dibutyryl-cAMP and theophylline 30 min before and 30 min after feeding. All mice were killed 1 h after their last injection. Total RNA was isolated from the liver and subjected to dot-blot analysis. Bars with no common superscripts are significantly different ($P<0.005$). B, Effects of mineral oil and cellulose ingestion on liver GRP78 mRNA abundance. Groups of six mice were fasted for 48 h and treated as follows: Fasted, mice were fasted for 48 h and killed; Fed, mice were fasted for 48 h, fed, and killed 1.5 h later; Fasted+cellulose, mice fasted for 48 h

were fed a mixture of cellulose and mineral oil, and killed 1.5 h later. Significance is indicated as in the legend to Fig. 5.

FIG. 7. Effects of adrenalectomy and dexamethasone administration on the expression and regulation of hepatic GRP78 mRNA. Groups of six mice were fasted for 48 h and treated as follows: Fasted+Sham, sham-operated mice were injected with vehicle IP 7.5 h and 1.5 h before they were killed; Fed+Sham, sham-operated mice were injected with vehicle IP 6 hours before and 30 min after feeding, and mice were killed 1 h after the last injection; Adx Fasted+Sham, adrenalectomized mice were injected with vehicle IP 7.5 h and 1.5 h before they were killed; Adx Fed+Sham, adrenalectomized mice were injected with vehicle IP 6 hours before and 30 min after feeding, and the mice killed 1 h later; Adx Fasted+Dex, adrenalectomized mice were injected IP with dexamethasone 7.5 h and 1.5 h before they were killed; Adx Fed+Dex, adrenalectomized mice were injected IP with dexamethasone 6 hours before and 30 min after feeding, and killed 1 h later. Significance is indicated as in the legend to Fig. 5.

FIG. 8. The hepatic gene expression profiles of old control, old CR, young control, and young CR mice. The mice weighed 37.2±1.9 g, 22.8±1.2 g, 26.0±2.8 g, and 19.4±1.6 g, respectively. The CR groups consumed approximately 50% fewer calories than their control counterparts post-weaning, as described. Levels of specific mRNA were determined using the Mu11KsubA and Mu11KsubB GeneChip arrays (Affymetrix, Santa Clara, CA) containing targets for approximately 12,000 known mouse genes and ESTs. The experiment tree function of GeneSpring 3.0 (Silicon Genetics, San Carlos, CA) was utilized to display the results. The horizontal axis represents the position of each gene assigned by the “gene tree” average-linkage hierarchical clustering algorithm of the program. Below the position assigned to each gene is a color-coded indication of its relative expression level, based on a continuous scale. Bright blue indicates no detectable expression, purple average expression, and bright red high expression. The average expression of each gene in each group is shown. The GeneSpring “experiment tree” clustering algorithm calculated an average-linkage hierarchical clustering dendrogram of the data for each group of mice, which is shown to the left of the expression profiles.

FIG. 9. Schematic representation of the hypothesis that CR acts by preventing age-related changes in gene expression. During aging, some genes become over expressed or under-expressed relative to their levels in young animals (lower and upper lines). Unchanged expression with age is represented by the horizontal line. These deviations are assumed to be deleterious. The important genes effected by CR, in this hypothesis, are the over- or under-expressed genes returned to youthful levels of expression (arrows). The numbers of genes and ESTs in each category are shown at the ends of the lower and upper lines. The number of known genes in each category returned to baseline expression by LT- and ST-CR are given after the colons. Long-term and short-term CR both acted to reverse or prevent 23 of the increases and 41 of the decreases. Thus, long-term LT-CR actually prevented the increased expression of only 30 genes and ESTs and the decreased expression of only 24 genes and ESTs.

FIG. 10. Average of pairwise comparison of the global gene expression correlation coefficient for each possible pair of mice

FIG. 11. The hepatic gene expression profiles of young CR, young control and streptozotocin (STZ)-treated mice. Levels of specific mRNA were determined using the MullKsubA and MullKsubB GeneChip arrays (Affymetrix, Santa Clara, CA) containing targets for approximately 12,000 known mouse genes and ESTs. The experiment tree function of GeneSpring 3.0 (Silicon Genetics, San Carlos, CA) was utilized to display the results. The horizontal axis represents the position of each gene assigned by the "gene tree" average-linkage hierarchical clustering algorithm of the program. Below the position assigned to each gene is a color-coded indication of its relative expression level, based on a continuous scale. Bright blue indicates no detectable expression, purple average expression, and bright red high expression. The average expression of each gene in each group is shown. The GeneSpring "experiment tree" clustering algorithm calculated an average-linkage hierarchical clustering dendrogram of the data for each group of mice, which is shown to the left of the expression profiles.

FIG. 12. Average of pairwise comparison of the global gene expression correlation coefficient for each possible pair of mice.

FIG. 13. The hepatic gene expression profiles of old CR, old control and aminoguanidine (AG)-treated mice. Levels of specific mRNA were determined using the MullKsubA and MullKsubB GeneChip arrays (Affymetrix, Santa Clara, CA) containing targets for approximately 12,000 known mouse genes and ESTs. The experiment tree function of GeneSpring 3.0 (Silicon Genetics, San Carlos, CA) was utilized to display the results. The horizontal axis represents the position of each gene assigned by the "gene tree" average-linkage hierarchical clustering algorithm of the program. Below the position assigned to each gene is a color-coded indication of its relative expression level, based on a continuous scale. Bright blue indicates no detectable expression, purple average expression, and bright red high expression. The average expression of each gene in each group is shown. The GeneSpring "experiment tree" clustering algorithm calculated an average-linkage hierarchical clustering dendrogram of the data for each group of mice, which is shown to the left of the expression profiles.

Detailed Description of the Preferred Embodiment

While the described embodiment represents the preferred embodiment of the present invention, it is to be understood that modifications will occur to those skilled in the art without departing from the spirit of the invention. The scope of the invention is therefore to be determined solely by the appended claims.

The effects of long term calorie restriction include increases in the rate of clearance of serum proteins, including glucose damaged serum proteins, from the blood as well as changes in gene expression. For example, long term calorie restriction down regulates the expression of certain chaperone genes, up regulates the expression of certain transcription factors and homeobox genes, increases expression of immune system genes, and increases genes enhancing genetic stability and apoptosis. These changes in gene expression correlate with an increase in apoptosis, reduced cancer incidence and increase the turnover of damaged and toxic serum proteins, reducing kidney and vascular damage with age or diabetes.

Molecular chaperones assist in the biosynthesis, folding, processing, and degradation of proteins. Many of the chaperone genes are stress inducible. Subsets of chaperones are induced by different physiological stressors. For example, the majority

of the known endoplasmic chaperones are induced by stresses that produce malformed or improperly glycosylated proteins in the ER. This unfolded protein response pathway also may adjust the level of protein trafficking through the ER to the level of ER chaperones. Other chaperones, such as the abundant cytoplasmic chaperone HSC70 are normally thought of as constitutively expressed. The present invention is based in part on the finding that certain chaperone genes are down regulated by calorie restriction (such regulation is thought to be mediated through the insulin and glucagon pathways). The expression of Erp72, Erp57, GRP 170, GRP78, GRP94, HSC70, Calnexin, and Calreticulin are particularly affected by calorie restriction.

The fasting mRNA and protein levels of nearly every ER chaperone studied were found to be significantly and consistently reduced in the livers of CR mice chronically fed a low calorie diet. In the case of GRP78, levels decreased by approximately 66%. Further, the reduction in chaperone mRNA levels was proportional to the reduction in calorie consumption. The fewer calories consumed, the lower the level of chaperone mRNA. We subsequently found that fasting chaperone mRNA levels changed over the course of 2 weeks in response to different levels of chronic calorie consumption. The more calories consumed per week, the higher the chaperone levels. Chaperone mRNA levels respond more rapidly to calorie consumption.

mRNA for most ER chaperones, and for the major cytoplasmic chaperone, HSC70, are dynamically responsive (within 1.5 h) to each meal, and to the number of calories consumed. Features of this induction distinguish it from the unfolded protein response. The feeding induction was observed in kidney and muscle tissue, as well as in the liver. Postprandial changes in glucagon, in conjunction with insulin, were found to be the key mediators of this induction.

Chaperone mRNA abundance responds within 1.5 h to caloric intake. Insulin and glucagon may be important for the response. This feeding response is rapid. By 1.5 hours after feeding, ER chaperone mRNAs were at or near their maximum level of induction. This feeding-related induction is not limited to one strain of mouse or to one species. Further, the response is found in tissues other than liver. Thus, it is a response which is generally important to the physiology of a variety of cell types in vivo.

Because many chaperones are relatively stable proteins, their protein levels change more slowly in response to caloric intake than their mRNAs. For example, GRP78 protein has a half-life of over 24 hours in cultured cells. We found that GRP78 protein levels change only over a span of several days in response to changes in average daily calorie consumption. In this way, many chaperones may effectively integrate the rapid mRNA responses to feeding into longer term changes in chaperone protein levels. Long term differences in average calorie consumption do lead to differences in the hepatic levels of both ER and some cytoplasmic chaperones.

RNase protection assays indicate that GRP78 mRNA is transcriptionally regulated in response to feeding. Similar RNase protection results were obtained with hepatic RNA from chronically CR mice. Thus, both feeding and CR transcriptionally alter the expression of the chaperone genes.

Puromycin led to partial induction of GRP78 mRNA. It is unlikely that induction of the mRNA by cycloheximide is due to stabilization of the transcript by polysome aggregation. While cycloheximide protects some mRNAs from inactivation and degradation in this way, puromycin does not. Rather, it inhibits translation by polysome dissociation. Thus, maintenance of low hepatic GRP78 mRNA levels most likely requires the action of an unstable repressor of GRP78 gene expression in fasted mice. In the presence of inhibitors of translation, this repressor may decay, releasing the gene from repression.

Second, there was no augmentation of GRP78 mRNA induction when feeding and inhibition of translation were combined. While partial induction of the mRNA was found in puromycin treated mice, feeding induced the mRNA to the same level found in the absence of the inhibitor. Further, cycloheximide induced the mRNA to the same extent. Without being bound to any particular mechanism, it is suggested that the inhibitors and feeding may induce the gene through a common pathway.

Third, since feeding fully induced GRP78 mRNA in puromycin treated mice, de novo protein synthesis is not required for the feeding response. Preexisting signaling and regulatory factors mediate the response. Fourth, the feeding response cannot result from a postprandial increase in protein trafficking through the ER. Enhanced ER de

novo protein trafficking can induce chaperone mRNA. However, no such increase could have occurred in the presence of puromycin.

Fifth, the unfolded protein and growth factor responses are not involved in the induction of chaperones by feeding. Cycloheximide blocks the unfolded protein and growth factor responses. We are aware of only one manipulation besides feeding capable of inducing ER chaperone mRNA in the presence of cycloheximide. GRP mRNAs are induced by cellular hypoxia in culture, and this induction is independent of cycloheximide treatment. Whether the feeding and hypoxia response share common molecular pathways is unknown at present.

Feeding is well-known to decrease glucagon and increase insulin levels. Both glucagon and dibutyryl-cAMP blunted the feeding induction of GRP78 mRNA. Thus, glucagon is a negative regulator of GRP78 expression in vivo. The feeding induction of GRP78 mRNA was significantly reduced in STZ-diabetic mice. Without being bound to any particular mechanism, this result and the absence of a feeding response in STZ-diabetic, dibutyryl-cAMP-treated mice indicate that the action of both hormones is required for the response.

Other effectors which are known to respond to feeding were also examined. Luminal stimuli can promote the release of gastrointestinal hormones. For this reason, we determined whether luminal filling with a non-digestible mixture of mineral oil and cellulose could stimulate chaperone expression. A small but significant response was found. However, insulin and glucagon have a much stronger effect on chaperone mRNAs, indicating they are the signals primarily responsible for the feeding response.

The feeding response was enhanced in adrenalectomized mice. These results suggest that other adrenal hormones, perhaps catecholamines, may partially blunt the chaperone mRNA response to feeding. However, the mechanism by which these hormones stimulate the feeding response is unknown at present.

Overall, feeding rapidly and strongly induced the mRNA for the major cytoplasmic chaperone, HSC70, and most ER chaperones examined. Feeding also induced ER chaperone mRNAs in at least three different tissues. Feeding and CR regulated chaperone mRNA abundance at the transcriptional level. Without being bound to any particular mechanism, feeding appeared to release chaperone gene

expression from the effects of an unstable inhibitor. Insulin was required, and glucagon and cAMP mediated the feeding response. Postprandial changes in glucagon levels may be the primary mediator of the response. Gastrointestinal and adrenal hormones, but not glucocorticoids also have a role in the feeding response.

5 Surprisingly, changes in gene expression are also observed with short-term calorie restriction. These changes in gene expression are virtually identical to the changes observed in long-term CR. Short-term calorie restriction occurs when switching a mature test animal to a diet which is about 50% less than a control diet for about 2-6 weeks. In a preferred embodiment, the test animal is a mature mouse and the
10 mature mouse is switched to a calorie-restricted diet at about 31 months. Preferably, an intermediate diet which is about 20-40% less than a control diet is employed for about two weeks before switching to a CR diet for an additional two weeks.

Both long term and short-term CR produces its profound effects on mammalian physiology by affecting the expression of genes. To identify as broadly as possible the
15 effects of caloric restriction on global patterns of gene expression, gene chip technology was utilized to characterize the effects of long and short term CR on the expression of approximately 11,000 mouse genes in the liver.

Liver is an attractive organ for study, since it contains a number of cell types, allowing assessment of the effects of CR on hepatocytes, which are primarily
20 responsible for the regulation of metabolism and blood sugar, neurons of the enteric nervous system, immune system cells in the blood, and vascular smooth muscle cells, among others. In liver, by far the predominant effect of caloric restriction is the activation of gene expression. In addition, after only four weeks of caloric restriction, the gene expression profile of old mature mice had been shifted from the profile
25 characteristic of fully fed "normo-aging" mice to the gene expression profile of slow aging, long term CR mice. In both long and short-term CR mice, changes were observed in gene expression of immune system genes, genes enhancing genetic stability and apoptosis, genes of the enteric nervous system and liver specific genes.

The methods of the present invention include the identification of interventions
30 that mimic the effects of calorie restriction. Particularly contemplated by the invention

are methods of identifying interventions that have an effect on life span, aging, and/or the development of age-related diseases and cancer.

In certain embodiments, such methods comprise obtaining cells, exposing them to an intervention, and observing whether the intervention affects the gene expression profile, levels of RNA, protein, or protein activity related to one or more biomarkers of aging. Preferably, such changes in gene expression, RNA, protein, or protein activity levels would occur within four weeks of the intervention. More preferably, such changes would occur within two weeks of the intervention, and most preferably, such changes occur within two days of the intervention. Such methods permit the identification of pharmacological or other means of achieving a metabolic state similar to the profile observed with long and short-term CR.

The methods of the present invention include the use of in vitro assays (including gene chip assays) as well as animal assays. Preferably, however, the methods are carried out in live mammals. For example, transgenic mice having enhanced chaperone expression may be used to measure an intervention's ability to reduce cancer, apoptosis, and/or life span. Alternatively, the present methods may be used to identify interventions that mimic calorie restriction simply by measuring the intervention's ability to alter gene expression for a particular gene or set of genes in live mammals. Such methods allow identification of effective interventions in a short period of time. Interventions identified by the methods of the present invention may be pharmacological, surgical or otherwise. Combinatorial chemistry may also be used in order to screen a large number of pharmacological compounds. In general, the interventions identified by the present invention should be effective in the treatment of cancer, diabetes, age-related diseases and/or the extension of life span.

While the described embodiment represents the preferred embodiment of the present invention, it is to be understood that modifications will occur to those skilled in the art without departing from the spirit of the invention. The scope of the invention is therefore to be determined solely by the appended claims.

EXAMPLES

Example 1

Long Term Calorie Restricted (LTCR) Animals and Treatments for Chaperone Studies

5 Female, 28-month old mice of the long-lived F₁ hybrid strain C3B10RF₁ have been described previously. Mice were weaned at 28 d, housed individually and subjected to one of two diets. The control diet consisted of casein (high protein), 207.0 g/kg, DL-methionine, 4.0 g/kg, dextrose monohydrate, 301.8 g/kg, corn starch, 290.0 g/kg, cellulose, 702. g/kg, brewer's yeast, 8.0 g/kg, Harlan Teklad Vitamin Mix #40060, 10.0 g/kg, Harlan Teklad AIN-76 Mineral Mix #170915, 35.0 g/kg, calcium carbonate (CaCO₃), 3.0 g/kg, magnesium oxide (MgO), 1.0 g/kg, sodium fluoride (NaF), 2.3 mg/kg, sodium molybdate (Na₂MoO₄·2H₂O), 0.5 mg/kg. The 50% restricted diet consisted of casein (high protein), 362.0 g/kg, DL-methionine, 7.0 g/kg, dextrose monohydrate, 172.03 g/kg, corn starch, 153.1 g/kg, cellulose, 83.6 g/kg, brewer's yeast, 14.0 g/kg, Harlan Teklad Vitamin Mix #40060, 17.5 g/kg, harlan Teklad AIN-76 Mineral Mix #170915, 61.25 g/kg, calcium carbonate (CaCO₃), 5.25 g/kg, magnesium oxide (MgO), 1.75 g/kg, sodium fluoride (NaF), 3.0 mg/kg, sodium molybdate (Na₂MoO₄·2H₂O), 0.9 mg/kg. From weaning, control mice were fed 4.8 g of the control diet on Monday through Thursday. On Friday they were fed 13.8 g of control diet. This feeding regimen provided 450 kJ/wk. From weaning, the 50% calorie restricted (CR) mice were fed 4.6 g of the restricted diet on Monday and Wednesday, and 6.9 g on Friday. This regimen provided 225 kJ/wk. Each dietary group received approximately equal amounts of protein, corn oil, minerals and vitamins per gram body weight. The amount of carbohydrates consumed varied between groups. Beginning 30 d before these studies, the control mice were fed 4.1 g (54.44 kJ) control diet daily at 0900 h. The 50% restricted mice were fed 2.3 g of restricted diet (32 kJ) daily at 0900 h. During this 30 d period, the control and restricted mice received approximately 15% and 50% less dietary energy than normally thought to be required for a typical mouse {Subcommittee on Laboratory Animal Nutrition & Committee on Animal Nutrition 1978 ID: 5480} All food was routinely consumed within 30 min.

Retired male Swiss-Webster breeder mice were purchased from Jackson Laboratories. Beginning 30 days before the studies, the mice were fed Monday and Wednesday 11 g and Friday 16.6 g of the control diet daily at 0900 h. In fasting-feeding studies, mice were deprived of food for 48 h, fed 5.5 g of the control diet at 0900 h, and killed 90 min later. The food was consumed within 30 min. Diabetes was induced by three weekly intraperitoneal injections of streptozotocin [10 mg/100 g body weight (b.w.)] in 50 mM sodium citrate, pH 4.5. Mice were diabetic one week after the last injection. Only mice with blood glucose level higher than 3 mg/ml were used. Mice injected with equivalent volumes of sodium citrate served as controls for the STZ-diabetic mice. Adrenalectomized and sham-operated mice were purchased from Jackson Laboratories. Dibutyl cAMP (Sigma; 18 mg/100 g b.w.), and theophylline (Sigma; 3 mg/100 g b.w.), glucagon (Sigma; 300 µg/100 g b.w.), dexamethasone (Sigma; 125 µg/100 g b.w.), cycloheximide (Sigma; 4 mg/100 g b.w.), and puromycin (Sigma; 10 mg/100 g b.w.), were administered intraperitoneally to mice as specified in the figure legends. Mice received two doses of each drug or drug combination. The first injection was administered 30 min before feeding, and the second injection was administered 30 min after feeding. Mice were killed 1.5 h after the start of feeding. Drug-injected mice consumed similar amounts of food as control animals during the feeding period. All animal use protocols were approved by the institutional animal use committee of the University of California, Riverside.

Example 2

RNA Isolation and Quantification for Chaperone Studies

Mice were killed and the livers, kidneys, and muscle were removed. Muscle from the hind legs and back was removed and pooled for each animal. Tissues were flash frozen in liquid nitrogen. Approximately 0.2 g of frozen tissue was homogenized for 40 s in 4 ml of TRI Reagent (Molecular Research Center, Cincinnati, OH) using a Tekmar Tissuemizer (Tekmar, Cincinnati, OH) at a setting of 55. RNA was isolated as described by the TRI Reagent supplier. RNA was resuspended in FORMAzol (Molecular Research Center) and Northern and dot blots were performed using 20 and 10 µg of RNA respectively. The RNA was analyzed using Northern blots to verify its

integrity. Dot blots were used to quantify mRNA levels (24; 27). Specific mRNA levels were normalized to the level of total RNA and/or mRNA present in each sample using hybridization with radiolabeled complementary DNA to 18S rRNA and/or transcription factor S-II, as indicated in the figure legends (12; 27). The murine ERp72 2.5 kb cDNA was excised with *Bam*HI from pcD72-1 (19). The 1235 bp murine GRP75 coding fragment was excised with *Hind*III from pG7z-PBP1.8 (6). A 1.5 kb coding fragment of GRP78 cDNA was produced by digestion of p3C5 with *Eco*RI and *Pst*I (15). A 1.4 kb hamster GRP94 coding fragment was produced by *Eco*RI and *Sa*/K digestion of p4A3 (15). A 664 bp coding fragment of rat calreticulin (nucleotides 148 to 812) was produced by PCR from GT10.U1 (23). The entire 2.4 kb cDNA of murine PDI was excised from pGEM59.4 with *Sac*I and *Bam*HI (19). A 1 kb coding fragment of hamster GRP170 cDNA was excised with *Eco*RI and *Xho*I from pCRtmII (16). The 1.9 kb cDNA of murine ERp57 was excised with *Hind*III and *Sst*I from pERp61 (18). The 1 kb cDNA of murine HSC70 was excised with *Pst*I from phsc1.5 (9). The 1.3 kb PEPCCK coding fragment was produced by *Sph*I followed by *Sa*/I digestions of pGEM5ZEP (a gift from Dr. Ganner D.K. Vanderbilt University School of Medicine, Nashville, TN). The fragments were isolated by agarose gel electrophoresis and radioactively labeled using a ³²P QuickPrime Kit (Pharmacia) according to the manufacturer's instructions.

Example 3

RNase Protection Assays for Chaperone Studies

A 223 base pair (bp) DNA fragment made up of 110 bases of intron 3 and all 113 bases of exon 4 of the mouse GRP78 gene was synthesized by PCR using genomic DNA as template and inserted into pT7/T3 (Ambion, Austin, Texas). Two probes of the junction region of intron 7 and exon 7 of the GRP78 gene were produced by PCR using mouse genomic DNA as template. A 257-base fragment including all of exon 7 and the first 113 bases of intron 7 was produced. A 200-base fragment including all of exon 7 and the first 56 bases of intron 7 also was produced. The T7 RNA polymerase promoter was ligated to these PCR fragments using a Lig'nScribe kit as described by the supplier (Ambion). These constructs were used as template for the synthesis of [³²P]-labeled

antisense RNA probes using a MAXIScript kit as described by the supplier (Ambion). RNase protection assays were performed using an RPA II kit as described by the supplier (Ambion). Hybridization of the 257-base RNA probe with GRP78 pre-mRNA protected all 257-bases corresponding to exon 7 and the first 113 bases of intron 7. Hybridization of the 200-base RNA probe to pre-mRNA protected 200-bases corresponding to all of exon 7 and the first 56 bases of intron 7. Hybridization of either probe to GRP78 mRNA protects the 143-bases complementary to exon 7. A 185- and a 277-bp cDNA fragment of S-II cDNA was synthesized and subcloned into pT7/T3 (12). [³²P]-labeled RNA probes for the sense and antisense transcripts were synthesized in vitro and RNase protection assays performed. Hybridization with S-II mRNA protected the entire 185- or 277-base region of the probes. Protection of only the sense strand probes was detected. Quantitation of the hybridized fragments was determined with ImageQuaNT (Molecular Dynamics, Sunnyvale, CA).

Example 4

Plasma Glucose and Insulin for Chaperone Studies

Plasma glucose, insulin, and glucagon concentrations were determined using Glucose [HK] 10 (Sigma, St. Louis, MO), Rat Insulin RIA and Glucagon RIA kits (Linco Research, St. Charles, MO), as described by the suppliers.

Example 5

Statistical Analysis for Chaperone Studies

The data shown in Figure 1 are expressed as means \pm SD for 5 mice at each time point. The effects of food deprivation and subsequent feeding on mice of each dietary group were analyzed using a one-way ANOVA followed by Fisher's test. The analysis determined whether individual time point means differed from time 0 means within each dietary group. It also determined the differences between the means of the control and CR groups at each time point. Differences of $P < 0.05$ were considered significant. Values are expressed as means \pm SD. Significance was determined with either Student's unpaired t-test ($P < 0.05$) or a one-way ANOVA followed by Fisher's or

Tukey's tests ($P < 0.01$). All statistical analyses were performed with Minitab Statistical Software (Minitab, State College, PA).

Example 6

Chronic and Acute Effects of Calorie Consumption on Hepatic Chaperone mRNA

Feeding of the fasted mice rapidly induced the abundance of GRP78 and ERp72 mRNA (Figures 1A and 1B). A large increase in chaperone mRNA was detected by 1.5 h after feeding, the first time point studied. The 24-h fasting levels (0 time) of GRP78 and ERp72 mRNA were lower in the CR mice. The response to feeding was kinetically different in control and CR mice. Thus, the amount of food consumed affects the kinetics of the response. The integrated level of GRP78 and ERp72 mRNA over the entire 24-hour period was also less in the CR than in control mice. Similar results were obtained when the effects of feeding on HSC70, ERp57, and calreticulin mRNA were determined (data not shown). Thus, this represents a common response of chaperone gene expression to feeding.

Example 7

Fasting-Feeding Induced Multiple Chaperone mRNAs in Multiple Tissues

Mice were fasted for 48 hours and refed for 1.5 hours. Hepatic GRP78 mRNA was induced approximately 3-fold after this time (Figure 2A). The mRNA for the other ER chaperones investigated, ERp57, ERp72, GRP94, GRP170, PDI, and calreticulin, and for the most abundant cytoplasmic chaperone, HSC70, also were induced by feeding (Figure 2A). HSC70 was induced by nearly 3-fold. No changes in the mitochondrial chaperone GRP75 was detected in this study. By examining chaperone levels in other tissues of fasted and fed mice, we found that the feeding-related chaperone induction extends to at least kidney and muscle (Figure 2B). GRP78 mRNA induction is shown in the figure (Figure 2B). HSC70 mRNA was also induced in these tissues (data not shown). In studies not shown, we have found that a similar induction of hepatic chaperone mRNAs occurs in rat. Thus, the response is shared by other species.

Example 8

CR Reduces the Abundance of the GRP78 Primary Transcript

5 RNase protection studies were used to investigate the responsiveness of the GRP78 mRNA and primary transcript to chronic differences in dietary calorie consumption. A probe was utilized for these studies designed so that the GRP78 primary transcript protected a 223 base RNA fragment representing the third intron-fourth exon boundary of the transcript (Figure 3A lane 1, upper band). The mRNA protected a 113 base fragment of the probe which represents the fourth exon of the gene (Figure 3A, lane 1, lower band). Much less of the 223 and 113 base GRP78 precursor and mRNA probes were protected by RNA from CR mice (Figure 3A, lanes 4-9). A probe for 185 bases of S-II mRNA was included in each sample as an internal control (Figure 3A, lane 3). S-II mRNA is unresponsive to CR or fasting-feeding (25). The unlabeled bands in Figure 3 represent RNase-resistant artifacts of the S-II probe (Figure 3A, lane 2).

15 When the amount of protected probe was quantified and normalized to the signal obtained from the S-II probe, it became clear that the abundance of the chaperone precursor and mRNA were decreased to the same extent in the CR mice (Figure 3B). The same conclusion was reached using a probe for the boundary regions of intron 7 and exon 7. Consequently, CR decreases either the rate of GRP78 gene transcription or the stability of the GRP78 primary transcript. The data are not consistent with blocked or paused GRP78 gene transcription or changes in the stability of the mRNA in CR mice.

Example 9

Fasting-feeding induction of the GRP78 primary transcript

25 RNase protection studies also were used to investigate the fasting-feeding response. RNA isolated 1.5 h after feeding protected much more of a 257 base fragment representing the exon 7-intron 7 boundary of the primary transcript than RNA isolated from fasted mice (compare Fig. 4A, lanes 10-12 to lanes 7-9). Similar results were obtained with a probe in which 200 bases representing the exon 7-intron 7 boundary were protected (compare Fig. 4A, lanes 16-18 to lanes 13-15). In each case, RNA from

refed mice also protected more of the 143 base fragment representing the exon 7 region of the mRNA (Fig. 4A). A probe for 277 bp of the S-II mRNA was present in each assay for use as an internal control.

Quantification of these data, and normalization of the S-II internal control demonstrated that the mRNA and the precursor RNA were induced by feeding to essentially the same extent (Fig. 4B and 4C). Similar results were obtained using the probe described earlier for the third intron-fourth exon boundary of the gene (data not shown). Without being bound to a specific mechanism, these data suggest the same molecular step is responsible for regulating the genetic responsiveness of chaperones to both acute and chronic changes in calorie consumption. This mechanism appears to involve changes in either the transcription or the stability of the primary transcript.

Example 10

Inhibitors of protein synthesis

To investigate the physiological basis for the fasting-feeding response, studies were performed using inhibitors of protein synthesis. Fasted mice were treated with a dose of cycloheximide or puromycin sufficient to inhibit greater than 95% of protein synthesis in the liver. Treatment with cycloheximide strongly induced GRP78 mRNA in fasted mice (Fig. 5A). GRP78 mRNA also was strongly induced in cycloheximide-treated, refed mice. Puromycin treatment modestly induced GRP78 mRNA in fasted mice (Fig. 5A). Feeding of puromycin treated mice fully induced the mRNA. Thus, induction by feeding does not appear to require de novo protein synthesis. Further, these results suggest that the lower chaperone mRNA levels in fasted mice may involve the action of a rapidly turning over factor.

The effects of the protein synthesis inhibitors on PEPCK mRNA also was determined as a positive control. The effects of fasting-feeding and cycloheximide treatment on this mRNA are well known. Fasting induced, and feeding repressed PEPCK mRNA, as expected (Fig. 5B). Also, as expected from published data, cycloheximide increased PEPCK mRNA in both fasted and refed mice through its effects on PEPCK mRNA stability. The effects of the inhibitors on PEPCK mRNA levels indicate the inhibitors were efficacious in these studies.

Example 11

Pancreatic hormones and glucose

The physiological hallmarks of the fasting-feeding transition are increased circulating insulin and decreased circulating glucagon. In the studies shown in Fig. 6, fasted and refed sham-injected mice had serum glucose concentrations of 84.4 ± 5.1 and 121.1 ± 8.0 mg/dl, serum insulin concentrations of 0.491 ± 0.203 and 1.3 ± 0.256 pmol/ml, and serum glucagon concentrations of 143 ± 22.4 and 81.4 ± 13.2 pg/ml, respectively.

To investigate whether these hormones are involved in the postprandial induction of GRP78 mRNA, the effects of cAMP, glucagon, and STZ-induced diabetes on the response were examined. Administration of either dibutyryl cAMP or glucagon reduced the response of GRP78 mRNA to feeding (Fig. 6A). Vehicle alone had no effect. Likewise, STZ-induced diabetes resulted in a blunted response to feeding although it did not modify the fasting level of GRP78 mRNA. When STZ-induced diabetes was combined with cAMP administration, the postprandial induction of GRP78 mRNA was obliterated. The mRNA remained at fasting levels. Without being bound to any particular mechanism, these results suggest that glucagon, acting to increase intracellular cAMP levels, suppresses chaperone gene transcription, or possibly GRP78 pre-RNA stability. Further, they suggest that insulin is required for full responsiveness of the chaperone genes to decreased intracellular cAMP.

Example 12

Luminal filling

Luminal filling can lead to the release of some gastrointestinal polypeptides. For this reason, we investigated the role of luminal stimuli on the chaperone mRNA response. Fasted mice were refed a nonnutritive paste of cellulose (a normal component of their regular diet) and mineral oil. The mice initially consumed the mixture enthusiastically. Stomach filling was confirmed for each mouse by postmortem examination. Cellulose-mineral oil consumption produced a minor but significant

increase in GRP78 mRNA (Fig. 6B), without producing a change in plasma glucose, insulin, or glucagon concentrations.

Example 13

Adrenal hormones

To investigate the role of adrenal hormones in the postprandial induction of GRP78 mRNA, we examined the effects of feeding in adrenalectomized mice (Fig. 7). Neither adrenalectomy nor sham surgery had any effect on the fasting levels of GRP78 mRNA. However, adrenalectomy increased the magnitude of the postprandial induction of the mRNA by approximately 2-fold over that found in refed, sham-operated mice. The feeding response of GRP94, ERp72, and GRP170 were also enhanced in the adrenalectomized mice (data not shown). Thus, the increase is a generalized ER chaperone response. Administration of dexamethasone to adrenalectomized mice increased the basal level of GRP78 mRNA during starvation, although not significantly (Fig. 7). However, dexamethasone administration had no effect on the feeding induction of the gene, suggesting its absence from adrenalectomized mice is not responsible for the enhancement of the feeding response.

Example 14

Preparation of test groups for short-term CR studies

Three groups of 30 month old mice were utilized for these studies. Male B6C3F₁ mice were maintained as described (Dhahbi et al. (1998) J. Gerontol 53A: B180). Mice were weaned at 28 days and housed individually. The composition of the defined diets used have been described. They are formulated so that only the amount of carbohydrate consumed varied between the CR and control mice. A group of control mice was fed a purified, semi-defined diet from 6 weeks of age. Control mice consumed approximately 105 kcal per week from weaning. This is approximately 10% less than the amount of food thought to support optimal growth, fertility and fecundity in mice {Subcommittee on Laboratory Animal Nutrition & Committee on Animal Nutrition 1978 ID: 5480}. Subjectively, these mice appeared neither fat or lean. A group of calorically restricted mice (CR mice) were fed a diet reduced in dietary carbohydrate such that the mice

consumed approximately 40% fewer calories than control mice. The long term CR mice consumed approximately 55 kcal per week from weaning. The short term CR mice were fed 105 kcal until the age of 29 months. They were then fed 80 kcal of control diet for 2 weeks, followed by 55 kcal of CR diet for two weeks. The mice were fed daily at 0900 hours. They had free access to water. For the studies, mice were fed a normal allotment of food Monday morning, and all the food was eaten within 45 minutes. They were fasted for 24 hours, and killed on Tuesday morning. At the time of use, the long term CR, short term CR and control mice weighed 22.8 ± 1.4 , 25.2 ± 0.3 and 37.2 ± 2.4 g, respectively. The mice were approximately 30 months old when killed.

Mice were killed by cervical dislocation and the liver rapidly removed and flash frozen in liquid nitrogen. Approximately 0.2 g of frozen liver was homogenized for 40 s in 4 ml of TRI Reagent (Molecular Research Center, Inc., Cincinnati, OH) using a Tekmar Tissuemizer (Tekmar Co., Cincinnati, OH) at a setting of 55. RNA was isolated as described by the supplier.

GeneChip oligonucleotide-based high-density array RNA expression assays were performed according to the standard Affymetrix protocol. The biotinylated, fragmented cRNA was hybridized to the MuhlKsubA and MuhlKsubB GeneChip arrays (Affymetrix, Santa Clara, CA), which contain targets for more than 11,000 known mouse genes and ESTs. The arrays were washed, stained and scanned. Scanned image analysis and data quantification were performed using the Affymetrix GeneChip analysis suite v3.2 at default parameter settings. Resultant data were normalized by global scaling.

Data analysis. Data sets were normalized further using GeneSpring 3.0 (Silicon Genetics, San Carlos, CA). Negative expression levels were forced to zero, and the expression data for each animal divided by the median of all experimental values for that chip above an expression level of 10. This step reduced chip-to-chip signal variation. Fold change in expression was calculated by dividing the mean of the expression levels in the CR groups by the mean of the expression levels in the control group.

Statistical analysis. To test for significance of the effect of diet on gene expression, one-way ANOVA was followed by Fisher's test ($P < 0.05$). Genes were placed in expression pattern groups (Table 2) for which they passed both tests. All statistical analyses were performed using Minitab Statistical Software.

Example 15

Gene Expression in long and short term CR mice

The global patterns of hepatic gene expression in the three groups of mice as displayed by GeneSpring 3.0, are shown in Fig. 8. The 11,000 genes assayed in the study are grouped according to both structure and function by the GeneSpring gene clustering algorithm across the horizontal axes of the figure. While this representation of the data cannot be subjected to statistical tests, subjective examination of this color coded representation of the data obtained immediately suggests that striking similarities exist in the gene expression profile of long and short term CR mice. Likewise, examination of the figure suggests that both CR expression profiles are very different than the profile of control mice. An average-linkage hierarchical clustering dendrogram calculated from the data by the GeneSpring clustering algorithm is shown to the left of the expression profiles. The dendrogram shows that the algorithm clustered the short- and long-term CR groups together, separated from the control group. This analysis agrees with our subjective interpretation of the expression profile.

Another aspect of this representation of the data was of interest. Significantly larger areas of blue were found in the expression profile of the control mice. These areas represent genes for which expression was not detectable. In both groups of CR mice, many of these regions were red, indicating higher levels of expression. Thus, a major effect of CR was the activation of specific gene expression.

To quantify the similarities in gene expression among groups of mice, a global expression correlation coefficient was calculated for each possible pair of mice. Table 1 shows the nine by nine matrix of these pairwise comparisons. The values are a measure of the similarities in gene expression between pairs of mice. Because the mice were genetically identical, the intra-group values provide a measure of the maximum correlations attainable. The inter-group correlations of the short- and long-term CR mice were similar to their intra-group correlations, indicating that gene expression in all

CR mice was similar. In contrast, the control mice have little correlation with the mice in either CR group. This analysis suggests that short- and long-term CR had highly similar effects on overall patterns of specific gene expression.

Table 1. Pairwise comparisons of the global gene expression correlation coefficient calculated for each possible pair of mice.

	CR	CONTROL	SWITCHED
CR	1.00* 0.25 0.32	0.01 0.04 -0.04	0.16 0.17 0.18
	1.0 0.27	-0.03 0.03 -0.01	0.13 0.12 0.18
	1.00	0.02 0.02 -0.02	0.18 0.14 0.21
CONTROL		1.00 0.29 0.42	0.0 0.03 0.07
		1.00 0.28	0.07 0.10 0.01
		1.00	-0.02 0.02 0.05
SWITCHED			1.00 0.24 0.18
			1.0 0.16
			1.00

Example 16

Long- and short-term CR induced expression of the same genes

The pseudogene function of GeneSpring 3.0, and statistical analysis of the data were utilized to sort the genes into one of seven possible categories of relative gene expression. These groups were: expression not different among groups; expression high in long-term CR, low in control, and high in short-term CR (termed, *high-low-high*) (Appendix A); expression low in long-term CR, high in control, and low in short-term CR (*low-high-low*) (Appendix B); expression low in long-term CR and control, but high in short-term CR (*low-low-high*) (Appendix C); expression high in long-term CR and control, and low in short-term CR (*high-high-low*) (Appendix D); expression high in long-term CR, and low in control and short-term CR (*high-low-low*) (Appendix E); and expression low in long-term CR and high in control and short-term CR (*low-high-high*) (Appendix F). The vast majority of the genes were not different among groups, and will not be discussed further.

Table 2 shows the number of genes and expressed sequence tags (ESTs) in each of the other groups. Ninety percent of these genes and ESTs were in the high-low-high

and low-high-low groups. In these groups, the short- and long-term CR expression patterns are most similar. The other 4 groups accounted for only 10% of the remaining genes and ESTs. These data indicate that short- and long-term CR produced remarkably similar effects on the expression of more than 11,000 hepatic genes and ESTs. A complete listing of the expression data for the genes and ESTs in each group is available (<http://www.biochemistry.ucr.edu/faculty/spindler.html/GeneChipData>) (This URL will be activated upon allowance of this application).

By far the most common response to short- and long-term CR was the high-low-high expression pattern. It accounted for nearly 86% of the genes and ESTs in the groups. Thus, the most common effect of short- and long-term CR was the activation of gene expression. To determine whether short- and long-term CR induced expression to the same degree in the high-low-high group, we tabulated the number of known genes for which expression was statistically the same in the two groups. In high-low-high, 303 of 340 known genes (89%) were expressed at the same level in the short- and long-term CR groups. For 26 of these genes (8%), expression in the long-term CR mice was statistically greater. For 11 genes (3%), expression was greater in the short-term CR group. Thus, short- and long-term CR induced the expression of the vast majority of these genes to the same levels.

Of the genes in the high-low-high group, 146 of 340 genes were activated from undetectable levels in the control mice to much higher, but very similar levels in both CR groups. Expression of these genes averaged 1.25 ± 0.25 and 1.23 ± 0.23 , in the short- and long-term CR groups, respectively. These observations reinforce the idea that short- and long-term CR have highly homologous effects on the expression of genes.

To further understand the genomic effects of CR, we identified the genes in the high-low-high group described above.

TABLE 2. GENES WHICH DIFFER FROM CONTROL IN RESPONSE TO CR

LT CR*	CONTROL	ST CR**	GENES	EST's	PER CENT
High	Low	High	340	860	85.7
Low	High	Low	23	37	4.3
High	High	Low	4	9	0.9
Low	Low	High	13	19	2.3
High	Low	Low	26	55	5.8
Low	High	High	9	6	1.1

* Long-term CR

** Short-term CR

Example 17Immune system activation: The immune theory of aging

Many of the genes which were induced by CR in the long and short term CR group were genes involved with immune system activation. Without being limited to any specific mechanism, this result provides support for the theory that the immune system plays a central role in the rate and many of the pathologies of aging. Slightly more than 130 T-cell receptor, IgG, IgA, IgD, IgK, and IgM, genes were present in the high-low-high group. The average fold relative expression of these mRNAs in the long and short term CR groups was 1.24 ± 0.86 and 1.23 ± 0.25 , verses 0.16 ± 0.16 in the

control group. Thus, CR increased immunoglobulin and T-cell receptor expression more than 10-fold. It is highly unlikely that this increase was due to an increase in the amount of blood in the CR livers. The level of globin mRNA found in these mRNA samples was actually reduced by about 20% in the long and short term CR groups. No statistically significant difference was found in the globin mRNA concentration in the blood of these animals.

Other changes in gene expression indicate that CR activates the immune system (Table 3). As can be seen in the table, both long and short term CR induced the expression of hemopoietic and lymphopoietic cytokines, hormones, signal transduction proteins, protein kinase modulators of the cell cycle and signal transduction, cell-surface receptors, and transcription factors. Not shown are a group of 20 immune cell specific genes known to be involved in endocytosis, cell adhesion, phagocytosis, potassium channels, lymphocyte activation, VDJ recombination, and immune cell activation which were strongly and significantly induced by CR (3- to 40-fold; $P \geq 0.037$). Together, these data evidence that CR enhances the activity of the immune system.

Table 3. Immune system genes activated by short- and long-term CR

<u>LTCR*</u>	<u>STCR*</u>	<u>P</u>	<u>GENE</u>
<u>Hormones / Cytokines / Chemokines</u>			
4	4	0.003	Antigen, B cell receptor; L43567
53	55	<0.001	Calcium/calmodulin-dependent protein kinase IV (<i>Camk4</i>); multifunctional serine-threonine protein kinase; T cells; X58995
>100	>100	<0.001	Chemokine (C-C) receptor 1 (<i>Cmkbr1</i>); growth inhibitory effects; liver and spleen; U28404
13	17	<0.001	Chemokine (C-C) receptor 5 (<i>Cmkbr5</i>); induces mobilization of intercellular calcium; beta-chemokine; leucocyte chemoattractant; liver, thymus, spleen, elsewhere; ET62976
>100	>100	0.003	Chemokine (C-X-C) receptor 4 (<i>Cmkbr4</i>); integral membrane G-protein-coupled receptor; chemotaxis and calcium flux; directs monocytes and lymphocytes to their target tissues; thymus, T cells, and monocytes; ET62920
19	21	0.002	Colony stimulating factor 1 (macrophage) (<i>Csf1</i>); receptor; liver; X06368
10	8	0.016	Complement receptor 2 (<i>Cr2</i>); Late pre-B cells; M35684
3	2	0.015	Interferon beta type 1; growth factor; T helper cell differentiation factor; antiviral; modulates immune response to foreign and self-antigens; immune system cells, others; V00755
11	10	<0.001	Interferon-related developmental regulator (<i>Ifrd1</i>); T cells; V00756
9	6	0.044	Interleukin 2 (<i>Il2</i>); stimulates proliferation of activated T lymphocytes; M16762
>100	>100	0.015	Interleukin 2 receptor (<i>Il2r</i>); T cells; M26271
2	2	0.014	Interleukin 6 (<i>Il6</i>); promotes B cell maturation to Ig-secreting cells; activation of T cells; some helper T cells and macrophages; X54542
5	6	0.004	Interleukin 7 (<i>Il7</i>); growth factor; B cell progenitors; X07962
4	3	0.046	Killer cell lectin-like receptor, subfamily A, member 3 (<i>Klra3</i>); Ly-49C; involved in graft rejection; subpopulation of natural killer cell; U49866
>100	>100	0.034	Killer cell lectin-like receptor, subfamily A, member 6 (<i>Klra6</i>); Ly-49F; NK cell surface antigen; determinant of IL-2-activated NK cell specificity; inhibitory receptor for interaction with MHC class I proteins; NK cells; U10092
13	11	<0.001	Lymphocyte antigen 84 (<i>Ly84</i>); signal transduction protein 2; T cells; D13695
5	6	0.007	Mast cell protease 7 (<i>Mcpt7</i>); released when mast cells are activated; mast cells; ET61471
3	2	0.037	Myc box dependent interacting protein 1 (<i>Bin1</i>); endocytosis and signal transduction; recycling synaptic vesicle components; macrophages, neurons, endocrine cells; U86405

<u>LT</u> CR*	<u>ST</u> CR*	<u>P</u>	<u>GENE</u>
>100	>100	<0.001	Paired-Ig-like receptor A1 (<i>Piral</i>); activates B lymphocytes, dendritic and myeloid-lineage cells; ET62839
5	4	0.027	Paired-Ig-like-receptor A6 (<i>Pira6</i>); appears to activate immunoglobulin-related receptor; B lymphocytes, myeloid lineage cells; ET62844
3	4	0.038	Preprosomatostatin (<i>Smst</i>); regulates T cell IFN-gamma production; macrophages, nervous system; X51468
>100	>100	<0.001	Protein tyrosine phosphatase, receptor type E (<i>Ptpre</i>); transmembranal, receptor-like form and a cytoplasmic, non-receptor form; hematopoietic tissues; ET61424
23	41	0.010	Proviral integration site (<i>Pim2</i>); serine/threonine kinase 2; cell proliferation; mitogen stimulated; long-term potentiation in hippocampus; immune and epithelial cells, CNS; L41495
<u>Receptors / Signal Transduction Proteins</u>			
11	8	0.001	Small inducible cytokine subfamily, member 2 (<i>Scyb2</i>); small inducible cytokine; macrophages; X53798
8	8	0.002	Son of sevenless 1, homologue 1 (<i>Drosophila</i>) (<i>Sos1</i>); Ras-specific exchange factor; T cells; Z11574
>100	>100	<0.001	Son of sevenless 2 homologue 2 (<i>Drosophila</i>) (<i>Sos2</i>); Ras-specific exchange factor; T cells; Z11664
>100	>100	0.002	Spleen protein kinase (<i>Syk</i>); signal transduction; lymphopoietic and haematopoietic cells, platelets, macrophages and neutrophils; ET61263
>100	>100	0.048	<i>Tbcl</i> ; domains homologous to <i>tre-2</i> oncogene and yeast mitosis regulators BUB2 and cdc16; nuclear localization; B lymphocytes; dendritic cells, myeloid-lineage cells; U33005
2	2	0.044	Thrombin receptor; transmembrane G-protein-coupled receptor; activated by serine protease cleavage; mitogen and apoptosis inducer following vessel injury; platelets, monocytes, endothelial cells, neuronal and glial cells; U36757
>100	>100	0.002	Wee1 homologue (<i>S. pombe</i>) (<i>Wee1</i>); inhibits entry into mitosis by phosphorylation of the Cdc2 kinase; lymphocytes; D30743
<u>Transcription Factors</u>			
38	35	<0.001	Abelson murine leukemia oncogene (<i>Abl</i>); nonreceptor tyrosine kinase; role in cell cycle progression, cell proliferation and differentiation; liver, B cells, others; X07540
>100	>100	0.047	Homeo box A4 (<i>Hoxa4</i>); transcription factor; embryonic spinal cord and adult testis; X13538
4	7	0.026	Homeo box B4 (<i>Hoxb4</i>); transcription factor; embryonic development; haematopoiesis; NK cells; M36654
6	10	0.029	Homeo box B7 (<i>Hoxb7</i>); transcription factor; embryonic development; haematopoiesis; developing embryo; blood, bone marrow, natural killer cells; X06762
8	9	<0.001	Homeo box C6 (<i>Hoxc6</i>); transcription factor; embryogenesis; haematopoiesis; liver and many other tissues; X16510

<u>LTCR*</u>	<u>STCR*</u>	<u>P</u>	<u>GENE</u>
40	36	0.001	Homeo box D1 (<i>Hoxd1</i>); transcription factor; neurogenesis; developing CNS and forelimb bud; X60034
>100	>100	<0.001	Nuclear factor of activated T cells, cytoplasmic 2 (<i>Nfatc2</i>); T cell transcription factor isoform B; T cells; U36575
5	5	0.001	SRY-box containing gene 4 (<i>Sox4</i>); Sox gene family transcription factor; thymus, bone marrow, gonads; ET62444
2	2	0.012	Zinc finger protein 79 (<i>Zfp79</i>); Kruppel type zinc finger putative transcriptional repressor; associates with RB in vitro; hematopoietic cells, perhaps others; U29513
<u>Primary Response Genes</u>			
>100	>100	0.005	Fos-like antigen-1 (<i>Fosl1</i>); spleenocytes; U34245
>100	>100	<0.001	Immunity associated protein, 38 kDa (<i>Imap38</i>); spleenocytes; Y08026
>100	>100	<0.001	Immunoresponsive gene 1(<i>Irg1</i>); activated by bacterial LPS treatment; macrophages; L38281
>100	>100	<0.001	Prostaglandin-endoperoxide synthase (<i>Ptgs2</i>); putative mediator of inflammation; induced by growth factors and cytokines; monocytes and fibroblasts; M88242
388	353	0.001	T-cell acute lymphocytic leukemia 2 (<i>Tal2</i>); putative basic helix-loop-helix transcription factor activated in T-cell acute lymphoblastic leukemia; T cells; M81077
>100	>100	<0.001	Tumor necrosis factor induced protein 3 (<i>Tnfip3</i>); putative helix-loop-helix transcription factor activated in T-cell acute lymphoblastic leukemia; lymphocytes; U19463
<u>Cell Adhesion / Membrane Components</u>			
>100	>100	0.002	ADP-ribosyltransferase 2a (<i>Art2a</i>); homologue of the rat T cell differentiation marker RT6; cell-cell signaling; cytotoxic T lymphocytes; X52991
9	9	0.013	Cadherin 9 (<i>Cdh9</i>); calcium-binding membrane glycoprotein; cell adhesion molecule; thymocytes; U69136
6	5	0.015	CD22 antigen (<i>Cd22</i>); mediates B cell interactions with endothelial cells; B cells; L16928
7	7	0.002	CD53 antigen (<i>Cd53</i>); pan-leukocyte antigen; cell membrane glycoprotein; thymocytes; X97227
40	36	<0.001	Erythrocyte protein band 7.2 (<i>Epb7.2</i>); involved in Na ⁺ /K ⁺ permeability of cells; spleen, lung, testis; X91043
8	8	0.006	Integrin alpha 4 (<i>Itga4</i>); cell adhesion; lymphocytes; X53176
>100	>100	<0.001	Mannose receptor, C type 2 (<i>Mrc2</i>); cell adhesion; antigen presentation; widespread tissue distribution, fetal liver; U56734
<u>Immune Cell Function</u>			
38	44	<0.001	Cytochrome b-245, beta polypeptide (<i>Cybb</i>); gp91phox; flavocytochrome mediating electron transfer from NADPH to molecular oxygen in the respiratory burst oxidase; phagocytes; U43384

<u>LT</u>	<u>TCR*</u>	<u>STCR*</u>	<u>P</u>	<u>GENE</u>
8	8	<0.001	Cytotoxic T lymphocyte-associated protein 2 beta (<i>Ctla2b</i>); homologue of cysteine protease proregion; T cells; X15592	
>100	>100	<0.001	GranzymeG (<i>Gzmg</i>); CTL serine protease 3; may play a role in cytolytic lymphocyte activation; T lymphocytes; X14092	
>100	>100	0.007	Helicase, lymphoid specific (<i>Hells</i>); replication, repair, recombination and transcription; T and B cells; U25691	
>100	>100	0.001	Mast cell protease 4 (<i>Mcpt4</i>); secretory granule serine protease; peritoneal and most connective tissue mast cells; M55617	
5	6	0.007	Mast cell protease 7 (<i>Mcpt7</i>); released when mast cells are activated; mast cells; ET61471	
8	8	0.005	Potassium voltage gated channel, shaker related subfamily, member 2 (<i>Kcna2</i>); T cells, myelinating Schwann cells; M30440	
3	3	0.003	Terminal deoxynucleotidyl transferase (<i>Tdt</i>); VDJ assembly; recombination; earliest stage B and T cells; X04123	

*Fold of control

5 Further support for this view was found in the liver specific genes which were
strongly induced in expression by CR (Table 4). Long and short-term CR significantly
enhanced the expression of the CD44 hyaluronan receptor gene, which has a role in
lymphocyte homing and activation. Likewise, CR activated the mRNA abundance of
the chemokine receptor 4, which is also involved in stimulating growth of pre-B cells;
the mannose receptor, C type 2, which is involved in antigen presentation; colony
stimulating factor 1, which is a macrophage growth factor; and proteasome 3, which
10 enhances the generation of class I binding peptides.

Table 4. Liver specific and ubiquitous genes

<u>LTCR*</u>	<u>STCR*</u>	<u>P</u>	<u>GENE</u>
<u>Cytokines / Growth Factors</u>			
12	7	0.003	C-Fos induced growth factor (<i>Fgf</i>); secreted growth factor; mitogenic and morphogenic activity; endothelial cells of liver during embryonic development; X99572
2	2	0.002	Fibroblast growth factor 2 (<i>Fgf2</i>); mitogen, differentiation and survival factor, angiogenic factor; stimulates hepatocyte proliferation and migration; hepatocytes, other cells; M30644
>100	>100	0.001	Fibroblast growth factor 3 (<i>Fgf3</i>); liver epithelial cells; Y00848
3	3	0.012	Fibroblast growth factor 7 (<i>Fgf7</i>); liver epithelial cells; ET62118
>100	>100	0.001	Follistatin (<i>Fst</i>); binds and inactivates activin; control of the inflammatory cascade; liver; Z29532
>100	>100	0.005	Inhibin beta B (<i>Inhbb</i>); transforming growth factor beta (TGF-beta) superfamily member; liver and elsewhere; X69620
>100	>100	0.001	Inhibin beta E (<i>Inhbe</i>); transforming growth factor beta (TGF-beta) superfamily member; liver and elsewhere; U96386
13	9	0.000	Interferon alpha gene family leukocyte (<i>Inf</i>); inhibition of cell proliferation; ubiquitous; M28587
3	2	0.015	Interferon beta type 1; growth factor; T helper cell differentiation factor; antiviral; modulates immune responses to foreign and self-antigens; ubiquitous; V00755
11	11	0.001	Interferon-beta (<i>Inf</i>); inhibitor of inflammation; liver and other cells; J00424
13	13	<0.001	Neurotrophin 3 (<i>Ntf3</i>); secreted protein; binds high affinity receptor trk C; may be involved in postnatal development; liver parenchymal cells, cerebellum, thymus, other; X53257
4	5	0.003	Preproendothelin 1 (<i>Edn1</i>); activates p38 MAP kinase and JNK; portal vein constriction; hepatic stellate cells, liver and arterial smooth muscle cell, others; U07982
10	15	0.003	Transforming growth factor, beta 2 (<i>Tgfb2</i>); cell proliferation; liver stellate cells; X57413
<u>Cell Surface Receptors</u>			
>100	>100	0.020	Bradykinin receptor beta (<i>Bdkrb</i>); G-protein-coupled membrane bound; T-kininogen modulation during acute phase protein synthesis; liver (ubiquitous); ET61559
2	2	0.017	CD44 antigen (<i>Cd44</i>); receptor for hyaluronan; cell surface glycoprotein; hyaluronan clearance from the blood; lymphocyte homing and activation; liver, CNS, other; U57612
>100	>100	<0.001	Chemokine (C-C) receptor 1 (<i>Cmkbr1</i>); mediates growth inhibitory effects of the chemokine; liver and spleen; U28404
12	8	0.013	Chemokine (C-X-C) receptor 4 (<i>Cmkar4</i>); primary receptor stromal cell-derived factor/pre-B growth stimulating factor; seven transmembrane domain receptor; liver and bone marrow; X99581

<u>LTICR*</u>	<u>STICR*</u>	<u>P</u>	<u>GENE</u>
>100	>100	<0.001	Fibroblast growth factor receptor 2 (<i>Fgfr2</i>); membrane-spanning tyrosine kinase; activated by three members of the FGF family; liver development; liver parenchymal cells and others; M86441
4	3	0.001	Leptin receptor (<i>Lepr</i>); transmembrane receptor; liver, lung, muscle, brain, other; ET61693
4	3	0.027	Melanocortin 5 receptor (<i>Mc5r</i>); G-protein-coupled receptor; stimulates adenylyl cyclase; widely expressed; X76295
3	4	0.029	Pancreatic polypeptide receptor 1 (<i>Ppyr1</i>); neuropeptide Y; peptide YY receptor; G-protein-coupled; liver; U40189
>100	>100	<0.001	Proteaseome 3 (<i>Psme3</i>); Ki antigen; cell proliferation; enhances generation of class I binding peptides; liver, broad tissue distribution; U60330
>100	>100	<0.001	Purinergic receptor P2X, ligand-gated ion channel 1 (<i>P2rx1</i>); mediate Ca(2+) influx; liver, ubiquitous; X84896
64	68	0.001	Ryanodine receptor 2 (<i>Ryr2</i>); endoplasmic reticulum membrane Ca2+ channels; controls cytosolic calcium levels; liver, cardiac muscle, neurons, most excitable cells; X83933
>100	>100	0.003	Transferrin receptor (<i>Trfr</i>); cell surface glycoprotein; cell growth; iron uptake; liver; X57349
<u>Signal Transduction / Cell Cycle / Cell Growth</u>			
38	35	<0.001	Abelson murine leukemia oncogene (<i>Abl</i>); nonreceptor tyrosine kinase; role in cell proliferation and differentiation; liver, B cells; X07540
>100	>100	0.006	Cyclin-dependent kinase inhibitor 1B (P27) (<i>Cdkn1b</i>); cell cycle; ubiquitous; U10440
35	40	0.003	Guanine nucleotide binding protein, alpha inhibiting 1 (<i>Gnail</i>); liver, cerebral cortex, others; U38501
>100	>100	0.013	Guanine nucleotide binding protein beta 4 (<i>Gnb4</i>); liver, brain, blood cell; M63658
>100	>100	0.001	Histamine receptor H1(<i>Hrh1</i>); coupled to phosphoinositide turnover-calcium mobilization signaling pathway; regulates IGF-I expression and cell proliferation; regulates thyroxine transport into hepatocytes; liver, brain, spleen (ubiquitous); D50095
>100	>100	0.002	Interferon-activated gene 204 (<i>Ifi204</i>); mediates antimicrobial, immunomodulatory and cell growth-regulatory activities of interferons; nucleoli; M31419
4	4	0.004	Kinase interacting with leukemia-associated gene (<i>Kis</i>); cytosolic phosphoprotein; integration of intracellular proliferation and differentiation signaling; ubiquitous; X82320
9	8	0.004	MAD homologue 5 (<i>Madh5</i>); downstream component in the TGF-beta family signaling cascade; liver development angiogenesis; liver; ET62570

<u>LTCR*</u>	<u>STCR*</u>	<u>P</u>	<u>GENE</u>
>100	>100	0.002	MAP kinase kinase kinase (<i>Map3k1</i>); serine-threonine kinase; regulates sequential protein phosphorylation pathways involving mitogen-activated protein kinases (MAPKs); ubiquitous; ET61257
>100	>100	0.002	Mitogen activated protein kinase 1 (<i>Mapk1</i>); signal transduction; cell proliferation, differentiation, and apoptosis; liver, ubiquitous; U85608
>100	>100	0.004	NIMA-related expressed kinase (<i>Nek1</i>); ubiquitous; S45828
3	3	0.041	Neuroblastoma ras oncogene (<i>Nras</i>); key component of growth signaling pathways; liver, wide tissue distribution; X13664
>100	>100	<0.001	Phosphatidylinositol 3-kinase regulatory subunit, polypeptide 1 (p85alpha) (<i>Pik3r1</i>); role in cell growth, differentiation, survival, and vesicular transport; liver; ET61628
>100	>100	0.003	Phospholipase C, gamma 1 (<i>Plcg1</i>); produces second messengers of signal transduction pathways related to cell proliferation; ubiquitous; ET63005
>100	>100	<0.001	Proteasome 3 (<i>Psmc3</i>); Ki antigen; cell proliferation; enhances the generation of class I binding peptides by altering the cleavage pattern of the proteasome; liver, neurons, broad tissue distribution; U60330
3	2	0.002	Protein tyrosine phosphatase, non-receptor type 16 (<i>Ptpn16</i>); growth factor-induced immediate early gene; dephosphorylates MAP kinase; liver parenchymal and vascular smooth muscle cells, others; X61940
11	12	0.001	Ras-GTPase-activating protein SH3-domain binding protein 2 (<i>G3bp2-pending</i>); essential for Ras signaling; ubiquitous; U65313
2	2	0.001	Rhodopsin kinase (<i>Rhok</i>); small GTPase and serine/threonine protein kinase; regulates actin cytoskeletal reorganization; enhances secretion; ubiquitous except for brain and muscle; U58513
15	14	0.018	Ros 1 proto-oncogene (<i>Ros1</i>); embryonic development; tyrosine kinase catalytic domains; expressed in neoplastic and fetal tissues; neoplastic and fetal tissues; U15443
6	4	0.010	SUMO-1 activating enzyme subunit 1; conjugates SUMO-1 (a small ubiquitin-like protein) to other proteins; modification of I Kappa B alpha blocks NF kappa B-dependent transcriptional activation; ubiquitous; AA162130
>100	>100	<0.001	Wingless related MMTV integration site 10b (<i>Wnt10b</i>); developmental regulation of cell growth and differentiation; ET62229
<u>Nuclear Receptors</u>			
19	17	0.016	Thyroid hormone receptor alpha (<i>Thra</i>); energy balance, thermoregulation, substrate uptake; liver; X07751
10	9	0.003	Glucocorticoid receptor 1 (<i>Gr11</i>); energy balance; substrate uptake; liver; X04435

<u>LT</u> CR*	<u>ST</u> CR*	<u>P</u>	<u>GENE</u>
45	42	<0.001	Nuclear receptor subfamily 2, group F member 1 (<i>Nr2f1</i>); COUP-TF1; orphan steroid hormone receptor; transcription factor; liver; X74134
>100	>100	0.010	Nuclear receptor subfamily 2, group F member 2 (<i>Nr2f2</i>); apolipoprotein regulatory protein 1; member of the COUP-family of steroid hormone orphan receptors; liver, lung, kidney; X76653
			<u>Transcription Factors</u>
4	3	0.016	Sine oculis-related homeobox 1 homologue (Drosophila) (<i>Six1</i>); AREC3; expressed in many cell-types during development; ET61028
9	7	0.003	cAMP responsive element binding protein 1 (<i>Creb1</i>); a mediator of cAMP responsive transcriptional regulation; ubiquitous; X67719
>100	>100	<0.001	Reticuloendotheliosis (<i>Rel</i>); c-rel: member of the Rel/nuclear factor (NF)-kappaB family of transcriptional factors; ubiquitous; X15842
>100	>100	<0.001	E4F transcription factor 1 (<i>E4f1</i>); DNA binding transcription factor; ubiquitous; X76858
4	4	0.026	Forkhead box C2 (<i>Foxc2</i>); transcription factor; hepatocytes; X74040
11	11	0.001	Homeo box A9 (<i>Hoxa9</i>); transcription factor; embryogenesis; M28449
>100	>100	0.003	Homeo box msh-like 1 (<i>Msx1</i>); transcription factor; early stage of eye developmental regulation in embryo; embryogenesis; X59251
2	3	0.003	Inhibitor of DNA binding 4 (<i>Idb4</i>); dominant negative regulator of bHLH transcription factors; myogenesis, neurogenesis D83 and haematopoiesis; liver and elsewhere; X75018
>100	>100	0.010	Myogen factor 5 (<i>Myf5</i>); transcription factor; embryonic liver and heart; X56182
6	8	0.003	Nuclear transcription factor-Y alpha (<i>Nfya</i>); CAAT-box DNA binding protein subunit A; involved in activation of many hepatic genes; ubiquitous; X55315
3	3	0.018	Paired box gene 2 (<i>Pax2</i>); Pax2 transcription factor; developing embryo excretory and CNS; X55781
12	13	0.003	RE1-silencing transcription factor (<i>Rest</i>); transcription factor; represses expression of neuronal genes; many nonneuronal cells and tissues; U13878
>100	>100	0.002	Sine oculis-related homeobox 1 homolog (Drosophila) (<i>Six1</i>); homeobox; development of limb tendons; skeletal and smooth muscle cells; X80339
>100	>100	0.005	SRY-box containing gene 12 (<i>Sox12</i>); transcription factor; Sox family plays important role in development; developing embryos; ET62446

<u>LTICR*</u>	<u>STICR*</u>	<u>P</u>	<u>GENE</u>
2	3	0.032	T-box 4 (<i>Tbx4</i>); DNA binding domain putative transcription factor; putative roll in inductive interactions during embryogenesis; embryonic development; ET62078
>100	>100	0.009	Trans-acting transcription factor 1 (<i>Sp1</i>); transcription factor; component of some hepatic glucose response elements, ubiquitous; X60136
>100	>100	0.024	Transcription elongation factor A 1 (<i>Tceal</i>); transcription elongation factor; liver; D00925
14	12	<0.001	Yes-associated protein, 65 kDa (<i>Yap</i>); transcription activator; ubiquitous; X80508
10	10	<0.001	Zinc finger protein 37 (<i>Zfp37</i>); putative transcription factor; peroxisome proliferator responsive; liver; X89264
>100	>100	0.009	Zinc finger protein 61 (<i>Zfp61</i>); putative transcription factor; liver, elsewhere; L28167
<u>Translation / Splicing / RNA Processing Factors</u>			
7	7	0.001	Cytoplasmic polyadenylation element binding protein (<i>Cpeb</i>); RNA binding protein that promotes polyadenylation and translational activation; ubiquitous; Y08260
4	4	0.011	Eukaryotic translation initiation factor 1A (<i>Eif1a</i>); ubiquitous; U28419
>100	>100	<0.001	Ribosomal protein L32, pseudogene (<i>Rpl32-ps</i>); ubiquitous; K02060
>100	>100	0.000	Ribosomal protein L7 (<i>Rpl7</i>); incorporated into 60 S subunit; ubiquitous; X57960
18	13	0.001	Signal recognition particle 9 kDa (<i>Srp9</i>); synthesis and translocation of membrane and secreted proteins into the endoplasmic reticulum; ubiquitous; X78304
>100	>100	0.004	Splicing factor arginine/serine-rich 3 (<i>Sfrs3</i>); splicing factor belonging to the highly conserved family of SR proteins; regulation of constitutive and alternative splicing; ubiquitous; X91656
<u>Chromatin Structure</u>			
4	5	0.009	Chromobox homologue (Drosophila HP1beta) (<i>Cbx</i>); modifies chromatin heritably activating or silencing genes; ubiquitous during development; X56690
>100	>100	0.028	Histone H1 subtype e (H1e); chromatin structure; ubiquitous; L04141
>100	>100	<0.001	Histone H1; chromatin structure; ubiquitous; J03482
109	70	<0.001	Histone H1b; chromatin structure; ubiquitous; ET62262
>100	>100	0.024	Histone H2A; chromatin structure; ubiquitous; X16495
4	3	0.030	Histone H2B; chromatin structure; ubiquitous; ET62908
7	8	0.006	Histone H3.1-D (H3-D) and histone H4-D (H4-D); chromatin structure; ubiquitous; U62672
>100	>100	<0.001	Histone H3.2-F (H3-F), histone H2a.1-F (H2a-F), histone H2b-F (H2b-F); chromatin structure; ubiquitous; U62669

<u>LTICR*</u>	<u>STICR*</u>	<u>P</u>	<u>GENE</u>
4	4	0.034	HpaII tiny fragments locus 9c (<i>Htf9c</i>); structural similarity with yeast nucleic acid-modifying enzymes; activated at the G1/S transition, and S phase; down-regulated in growth arrested cells; liver (ubiquitous); X56044

*Fold of control

Example 18

CR stimulates the expression of genes enhancing genetic stability and apoptosis

5 The accumulation of genetic damage has been postulated to be a cause of aging. Without being limited to any specific mechanism, CR has been postulated to either reduce the rate of accumulation of genetic damage, or to enhance its rate of repair. Both long and short term CR enhanced the expression of numerous genes associated with DNA repair (Table 5). These genes included *Xpa*, which is involved in nucleotide excision DNA repair; and the *Brca2* gene, which is important in DNA double-strand break repair and DNA damage-induced cell-cycle checkpoint activation.

10 A theory of aging closely related to the DNA damage theory proposes that the reduction of apoptosis with age, and its restoration with CR plays an important role in aging. This hypothesis proposes that the accumulation of damaged cells with age contributes to aging itself and to the onset of the diseases of aging. Long and short term CR greatly enhanced the expression of a number of genes which choreograph the progression of a cell through the apoptotic pathway (Table 5). These genes included *Casp1*, *Casp3*, *Bax*, and *Bcl2* which code for key components of the apoptotic pathway.

Table 5. Genetic stability and apoptosis

<u>LTCR*</u>	<u>STCR*</u>	<u>P</u>	<u>GENE</u>
<u>DNA Replication / Repair</u>			
9	8	<0.001	Antigenic determinant of rec-A protein (<i>Kin</i>); Kin17; DNA-binding nuclear protein upregulated in response to UV and ionizing radiation; accumulated in the nucleus of proliferating cells; ubiquitous; X58472
>100	>100	0.001	Breast cancer 2 (<i>Brca2</i>); DNA double-strand break repair and DNA damage-induced cell-cycle checkpoint activation; ubiquitous; ET62746
3	3	0.029	DNA primase p49 subunit (<i>Prim</i>); DNA replication; liver (ubiquitous); X74351
6	5	0.009	Mut L homologue 1 (E. Coli) (<i>Mlh1</i>); transcription-coupled nucleotide excision repair; cell cycle checkpoint control; ubiquitous; ET63479
3	3	0.025	Xeroderma pigmentosum complementation group A (<i>Xpa</i>); nucleotide excision DNA repair; ubiquitous; X7435
<u>Apoptosis</u>			
>100	>100	0.001	B-cell leukemia/lymphoma 2 (<i>Bcl2</i>); suppresses apoptosis by controlling mitochondrial membrane permeability; many cells and tissues; L31532
>100	>100	<0.001	Bcl2-associated X protein (<i>Bax</i>); pro-apoptotic activity; can form channels in lipid membranes; many cells and tissues; L22472
5	4	0.033	Caspase 1 (<i>Casp1</i>); cysteine protease mediator of apoptosis; ubiquitous; U04269
2	3	0.000	Caspase 3 (<i>Casp3</i>); cysteine protease mediator of apoptosis; ubiquitous; ET63241
3	4	0.005	Cyclin G (<i>Ccng</i>); augments apoptosis; target gene of P53; liver, elsewhere; Z37110
>100	>100	<0.001	Fused toes (<i>Fts</i>); a gene related to ubiquitin-conjugating enzymes; suggested role in apoptosis during development; expression distribution poorly defined; X71978
22	21	<0.001	P53 specific ubiquitin ligase 2 (<i>Mdm2</i>); promotes ubiquitination and proteasome degradation of p53; inactivation by stress causes cell cycle arrest and apoptosis; liver, elsewhere; X58876
>100	>100	<0.001	RNA-dependent EIF-2 alpha kinase; double-stranded RNA-dependent protein kinase; key mediator of antiviral effects of interferon; ubiquitous; ET61211
>100	>100	0.009	Tumor necrosis factor (<i>Tnf</i>); Proapoptotic factor in liver; X02611

*Fold of control

Example 19

CR Activation of Genes of the Enteric Nervous System

The liver is a highly innervated organ. This innervation includes elements of the enteric nervous system, as well as sympathetic innervation in the small arteries of the hepatic mesentery. This nervous innervation is essential to the activity of the liver. Nervous innervation has a role in the release of glucose by hepatocytes in response to insulin. As shown in Table 6, long and short term CR activated the expression of a large number of genes associated with the membrane receptor signaling, including membrane receptors for protein and small molecule neurotransmitters, and for cell growth and maintenance factors. CR induced the expression of genes for both phosphatases and kinases involved in signaling by these receptors. CR also induced the expression of four neuronal tissue specific transcription factors (Table 6).

CR enhanced the ability of liver neurons to transduce and respond to nervous system signaling. Eight genes for membrane channels were induced, including genes for sodium, potassium, and water channels (Table 6). Also induced were a number of integral membrane proteins such as proteolipid protein and cadherin 8, as well as the products of 5 genes for molecular motors which are probably involved in neural plasticity and remodeling. These proteins included 4 members of the dynein, axon, heavy chain family. Our results are consistent with the idea that CR increases the remodeling and activity of hepatic nerves after only 4 weeks.

Table 6. Neuronal Cell Specific Genes

<u>LTCR*</u>	<u>STCR*</u>	<u>P</u>	<u>GENE</u>
			<u>Signal Transduction</u>
19	18	0.001	5-hydroxytryptamine (serotonin) receptor 1E beta (<i>Htr1eb</i>); G-protein-coupled receptor; CNS; Z14224
>100	>100	<0.001	Activin A receptor, type 1B (<i>Acvr1b</i>); limb development; embryo brain, dorsal root ganglia, spinal cord, vibrissae, elsewhere; Z31663
5	5	0.005	Ankyrin 3 (<i>Ank3</i>); implicated in Na(+) channel clustering and activity; neuronal axons, wide distribution; ET62740
3	3	0.022	Bone morphogenetic protein receptor, type 1B (<i>Bmpr1b</i>); activin receptor-like kinase-6; serine-threonine kinase; CNS, muscle, blood vessels, others; Z23143
5	6	0.004	Discs, large homologue 1 (Drosophila) (<i>Dlgh1</i>); role in localization and function of glutamate receptors and K(+) channels; neurons, epithelial cells; ET61665
67	70	0.001	Eph receptor A7 (<i>Epa7</i>); developmental kinase 1; member of receptor tyrosine kinase family; brain, testes and spleen; X79082
>100	>100	0.001	Fibroblast growth factor 9 (<i>Fgf9</i>); autocrine/paracrine growth factor; embryonic neural cell differentiation; adult and developing neuronal cells, epithelial cells, others; U33535
14	15	<0.001	Fibroblast growth factor homologous factor 1 (<i>Fgfl</i>); nervous system development and function; highest in brain and skeletal muscle; U66201
17	19	0.003	G-protein-coupled receptor, family C, group 1, member H (<i>Gprclh</i>); glutamate receptor, metabotropic 8; CNS, glial cells, retina, olfactory bulb, stellate/basket cells; U17252
28	29	<0.001	Gamma-aminobutyric acid (GABA-A) receptor, subunit beta 3 (<i>Gabrb3</i>); links binding of GABA to inhibitory chloride flux; CNS; U14420
12	11	<0.001	Glutamate receptor, ionotropic, kainate 1 (<i>Grik1</i>); CNS; X66118
>100	>100	0.007	Gonadotropin releasing hormone receptor (<i>Gnrhr</i>); G-protein-coupled receptor; activates MAPK cascades; brain, anterior pituitary, reproductive organs; L28756
4	3	0.018	H6 homeo box 2 (<i>Hmx2</i>); specification of neuronal cells; developing CNS; S80989
>100	>100	0.001	Histamine receptor H1 (<i>Hrh1</i>); coupled to phosphoinositide turnover-calcium mobilization signaling; regulates IGF-I expression, cell proliferation, neural function; neurons, liver, elsewhere; D50095
64	73	<0.001	Neuropeptide Y receptor Y6 (<i>Npy6r</i>); regulates energy balance through its orexigenic, antithermogenic, and insulin secretagogue actions; neurons, vascular smooth muscle cells; U58367
>100	>100	<0.001	Paired-Ig-like receptor A1 (<i>Pir1</i>); activating receptor on B lymphocytes; dendritic and myeloid-lineage cells; ET62839

<u>LTCR*</u>	<u>STCR*</u>	<u>P</u>	<u>GENE</u>
4	4	0.003	Preproglucagon (<i>Gcg</i>); glucagon-like peptides I and II; neuropeptide; CNS, pancreatic alpha cells, ileum; Z46845
>100	>100	0.013	Protein kinase, cGMP-dependent, type II (<i>Prkg2</i>); signal transduction; brain, kidney, small intestine, colon; L12460
>100	>100	0.001	Protein tyrosine phosphatase, receptor type, M (<i>Ptprm</i>); expressed in capillaries in developing neural tissue, lung; X58287
>100	>100	<0.001	Relaxin precursor (<i>Rln</i>); insulin gene family; remodeling of collagen; brain, uterus, prostate, pancreas and kidney; Z27088
>100	>100	<0.001	Ryanodine receptor 3 (<i>Ryr3</i>); intracellular Ca ²⁺ channels; neurons, skeletal and smooth muscle; ET61090
<u>Neuronal Tissue Specific Transcription Factors</u>			
>100	>100	<0.001	Atonal homologue 5 (Drosophila) (<i>Atoh 5</i>); neurogenin 3; transcription factor; neuroD-related bHLH protein; CNS; U76208
19	18	0.003	Embigin (<i>Emb</i>); DNA-binding transcription factor; class VI POU domain; CNS; D13801
>100	>100	0.026	Paired box gene 6 (<i>Pax6</i>); transcription factor; development of CNS, eye; X63963
>100	>100	<0.001	Zinc finger protein 2 (<i>Zfp2</i>); <i>Mkr-2</i> ; differentiation and/or maintenance of neurons; central and peripheral neurons; Y00850
<u>Channels</u>			
4	3	0.007	Aquaporin 4 (<i>Aqp4</i>); allows water and small solutes through plasma membrane; brain and other tissues; U48397
5	6	0.004	Discs, large homologue 1 (Drosophila) (<i>Dlgh1</i>); localization and function of glutamate receptors and K(+) channels; neural synapses; ET61665
22	25	0.001	Gap junction membrane channel protein beta 6 (<i>Gjb6</i>); connexin 30; forms transmembranous gap junction channels between adjacent cells; brain, skin; ET63385
11	11	0.001	K+ channel beta-subunit, ion channel; brain and kidney; X97281
14	16	0.001	Potassium inwardly-rectifying channel, subfamily J, member 6 (<i>Kcnj6</i>); neurons; ET61642
8	8	0.005	Potassium voltage gated channel, shaker related subfamily, member 2 (<i>Kcna2</i>); T cells, myelinating Schwann cells; M30440
27	28	<0.001	Sodium channel 27; brain; L42340
11	11	<0.001	Sodium channel, type X, alpha polypeptide (<i>Scn10a</i>); brain, unmyelinated axons; Y09108
<u>Molecular Motors</u>			
2	2	0.004	Dilute lethal-20J; Class-V myosin; vesicular membrane trafficking; transport of endoplasmic reticulum vesicles in neurons; M33467
7	8	0.001	Dynein, axon, heavy chain 1 (<i>Dnahc1</i>); dyneins are molecular motors that drive the beating of cilia and flagella; brain, trachea, testis; ET63395
>100	>100	<0.001	Dynein, axon, heavy chain 3 (<i>Dnahc3</i>); brain, trachea, testis; ET63399

<u>LT</u> CR*	<u>ST</u> CR*	<u>P</u>	<u>GENE</u>
5	6	0.013	Dynein, axon, heavy chain 6 (<i>Dnahc6</i>); brain, trachea, testis; ET63402
4	5	0.002	Dynein, axon, heavy chain 9 (<i>Dnahc9</i>); brain, trachea, testis; ET63405
<u>Cell Surface and Secreted Proteins</u>			
>100	>100	0.001	Cadherin 8 (<i>Cdh8</i>); adhesion molecule; subdivisions of the early CNS and thymus; ET63017
37	36	<0.001	Glutamic acid decarboxylase, 67 kD; responsible for gamma-aminobutyric acid synthesis; brain, islets; Y12257
2	2	0.011	Glypican 4 (<i>Gpc4</i>); cell surface heparin sulfate proteoglycan; role in regulation of neural cell transition from proliferation to differentiation; neurons; X83577
19	20	<0.001	Neurexophilin 2 (<i>Nxph2</i>); neuronal glycoprotein; binds to alpha-neurexins; brain; U56650
13	13	<0.001	Neurotrophin 3 (<i>Ntf3</i>); secreted protein; maintenance and plasticity of neurons; enteric neurons, others; X53257
43	41	0.001	Proteolipid protein (<i>Plp</i>), main integral protein of myelin; CNS; X07215
4	4	0.043	Sema domain, immunoglobulin domain (Ig), short basic domain, secreted, (semaphorin) 3E (<i>Sema3e</i>); glycoprotein involved in embryonic development; developing neural tubes, lungs, skeletal elements; ET63410
>100	>100	<0.001	Sema domain, seven thrombospondin repeats (type 1 and type 1-like) (<i>Sema5a</i>); axonal guidance; early embryogenesis; X97817
<u>Other Genes</u>			
6	7	0.015	Disabled homolog 1 (Drosophila) (<i>Dab1</i>); adaptor molecule in neural development; neuronal and hematopoietic cells; ET63156
23	24	<0.001	Galanin (<i>Gal</i>); neuropeptide; enhances hepatic glucose production; hepatic nerves and elsewhere; L38580
3	4	0.006	Netrin 1 (<i>Ntn1</i>); axon outgrowth-promoting protein; guidance molecule; guides growing axons in development; CNS; U65418
127	129	<0.001	Nucleosome assembly protein 1-like 2 (<i>Nap1l2</i>); <i>Bpx</i> ; brain; X92352
>100	>100	<0.001	Proteasome 3 (<i>Psme3</i>); Ki antigen; cell proliferation; enhances generation of class I binding peptides; liver, neurons, elsewhere; U60330
58	58	<0.001	UDP-glucuronosyltransferase 8 (<i>Ugt8</i>); cerebroside and sulfatide biosynthesis; CNS and peripheral nervous system; X92122

*Fold of control

Example 20

Induction of other liver specific genes by CR

Of the approximately 200 genes reported to be expressed either liver specifically or ubiquitously, 13 code for cytokines or growth factors; 12 for cell surface receptors; 21 for signal transduction, cell cycle or cell growth related proteins; 4 for nuclear receptors, 20 for transcription factors; 6 for translation, splicing, or RNA processing related factors; and 9 for chromatin structure related genes (Table 4). The overall pattern of genes induced in this group of genes suggests that CR stimulates the growth, remodeling and responsiveness of liver cells to signaling systems. These results are consistent with those found for neuronal genes, discussed above.

Both long and short term CR induced the expression of the cell growth factors *Tgfb2*, *Fgf1*, *Fgf2*, *Fgf3*, *Fgf7*, *Fgf9*, *Figf*, *Inhbb*, *Inhbe*, and 3 interferon-related genes. Likewise, a large number of genes coding for cell cycle regulation were induced by CR. These genes included *Ptpn16*, *Nek1*, *Plcg1*, *Map3k1*, *Mapk1*, *Madh5*, *Wnt10b*, *Abl*, and others. Without being limited to any specific mechanism, the hypothesis that CR induces cell remodeling and growth of liver cells is further supported by the observation that both long and short term CR very strongly induced the expression of 7 histone genes. In 6 cases, these mRNA levels were induced from undetectable, or nearly undetectable levels. Two other genes which appear to be associated with chromatin structural modification were also strongly induced by CR (*Htf9c* and homologous to *Drosophila Hpl1*; Table 4). Further evidence that CR enhances cell division and remodeling is the up regulation of the mRNA for the transferrin receptor, which mediates cellular iron uptake, a process essential for cell growth and division.

Three receptor mRNAs associated with energy balance were induced by CR. Two of these were for neuropeptide Y receptor Y6 (Table 6) and pancreatic polypeptide receptor 1, and one was for the leptin receptor (Table 4).

Example 21

Global hepatic gene expression profile

We have tested the hypotheses that CR produces similar effects on gene expression early and late in life by examining the effects of aging and caloric intake on

the expression of approximately 12,000 genes and ESTs in the liver of old (27-month-old) and young (7-month-old), control and CR mice, using GeneChip microarrays. We found that CR produced a massive reprogramming of gene expression early and late in life. The patterns of expression induced by CR in young and old mice were highly homologous. Comparison of gene expression in the groups of mice indicated that CR only prevented age-related changes in the expression of a few genes. Examination of the genes involved does not support the idea that they have a principle role in the age-retarding effects of CR. Together, the results do not support the idea that CR acts principally to prevent deleterious age-related changes in gene expression. Instead, CR induces a highly-homologous, major reprogramming of gene expression in animals of all ages.

The average global hepatic gene expression profile for each group of mice, displayed using GeneSpring 3.0 (Silicon Genetics, San Carlos, CA), is shown in Figure 8. The GeneSpring experiment tree algorithm clustered gene expression in the young and old CR mice together, and separately clustered expression in the young and old control mice together. These results indicate that that the effects of the CR diet on gene expression was significantly greater than the effect of age. Further, these data indicate that CR produced homologous effects on gene expression in the young and old mice.

Table 7. Pairwise comparisons of the global gene expression correlation coefficients for each possible pair of mice.

	Old-CR	Old-Control	Young-CR	Young-Control
Old-CR	$0.53 \pm 0.02^*$	-0.09 ± 0.02	0.41 ± 0.04	-0.10 ± 0.03
Old-Control		0.28 ± 0.06	-0.11 ± 0.03	0.23 ± 0.02
Young-CR			0.41 ± 0.01	-0.08 ± 0.02
Young-Control				0.22 ± 0.02

*All values average values, \pm SD are calculated as the Log (1+ the mRNA level)

These conclusions are supported by comparison of the correlation coefficients calculated from the expression data for each possible pair of mice in the study (Table 7). Because the mice were genetically identical, intra-group values provide a measure of the maximum correlations attainable. Inter-group values measure the similarity between groups. Inter-group comparisons between young and old CR and control mice indicated that gene expression in all CR mice was highly homologous, regardless of the age of the animals. Likewise, regardless of age, the intra-group expression patterns of the control mice were highly homologous. In contrast, there was no intra-group correlation between mice in different dietary groups, regardless of age. These data indicate that the number of calories consumed, but not age was the major influence in determining the global patterns of gene expression in these mice. This novel result is further supported by the analysis described below.

The patterns of gene expression in the mice were further evaluated by successive application of the Venn Diagram Function of GeneSpring 3.0, one-way ANOVA, and Fisher's test ($P < 0.05$) to the levels of expression of each gene and expressed sequence tag (EST) in the 4 groups of mice. These operations sorted the genes and ESTs into one of 9 possible categories (Tables 8A and B). Only statistically significant differences of 2-fold or more are shown. The expression of most genes and ESTs were not affected by

either CR (~80% unchanged) or aging (95% unchanged). Of the genes and ESTs which did changed expression among the groups, 5-times as many genes and ESTs changed expression level in response to CR (2456) as changed in response to age (561). Of the genes and ESTs responsive to CR, most (40%) were upregulated in both young and old mice. Two other groups of genes and ESTs were upregulated either in old mice only (28% of the genes that changed expression), or in young mice only (19% of the genes that changed expression). An even smaller number of genes and ESTs were down regulated by the CR diet in young or old mice (13% of the genes that changed expression).

10

Table 8. The effects of age and diet on gene expression

a. Diet Effect

Old (CR/Control)*

Young
(CR/Control)*

	Up**	Unchanged	Down**	Total
Up**	975 (8.1%***)	473 (3.9%)	0	1448
Unchanged	685 (5.7%)	9587 (79.6%)	172 (1.4%)	
Down**	0	105 (0.9%)	46 (0.4%)	151
Total	1660		218	

*Fold change of average mRNA levels of Old/Young mice

** Fold change of 2-fold or greater

***Percent of total genes and ESTs measured in study

b. Age Effect

CR (Old/Young)*

Control
(Old/Young)*

	Up**	Unchanged	Down**	Total
Up**	6 (0.05%***)	136 (1.1%)	2 (0%)	144
Unchanged	186 (1.5%)	11482 (95%)	112 (0.9%)	
Down**	1 (0%)	113 (0.9%)	5 (0.04%)	119
Total	193		119	

*Fold change of average mRNA levels of Old/Young mice

** Fold change of 2-fold or greater

***Percent of total genes and ESTs measured in study

Example 22

208 Genes greater in CR in both young and old

Three novel conclusions can be drawn from these data. First, CR induced a substantial age-independent reprogramming of gene expression. A large number of genes and ESTs (975) were up regulated by CR in both young and old mice (Table 8A). In this group, 208 were known genes (See Appendix G) All of these known genes were among the group of 340 genes induced in 30 month old mice by both long-term CR (LT-CR; life-long) and short-term CR (ST-CR; only 4 weeks of CR). This highly reproducible, age-independent, responsiveness to CR suggests to us that these genes and ESTs are likely to mediate the life- and health-span extending effects of CR. At a minimum, the dietary responsiveness of these genes can be used as a gauge of the effectiveness of other treatments in reproducing the effects of CR on global patterns of gene expression. Further, because 90% of the genes and ESTs induced by lifelong CR (which includes the age-independent and age-dependent genes and ESTs) can be induced after only 4 weeks of CR, the vast majority of the genetic reprogramming induced by CR can be reproduced rapidly.

Example 23

142 genes Up in young CR but not in old CR

There is a second novel conclusion which can be drawn from the results in Table 8A. CR produced some "age-dependent" reprogramming of gene expression in both young and old mice. Of the 473 genes and ESTs induced by CR only in young mice, 142 are known genes (Appendix H) These results indicate that this subset of genes was also CR responsive in old mice, but not to sufficient levels that they were distinguished statistically from control expression levels in these studies. Thus, Table 8A overestimates the number of young-specific induced genes by approximately 25%. Of the young-specific genes, 8% are involved in transcriptional regulation; 5% are growth factors, cytokines or hormones; 18% are involved in signal transduction or cell cycle regulation; 14% are involved in embryogenesis and development; 14% are involved in cellular adhesion, or are components of the extracellular matrix or membrane; 7% are channels or ion pumps; 3% are involved in extracellular transport or secretion; 3% are

involved in metabolism; 3% in DNA replication, repair or apoptosis; 3% in chromatin structure; 9% in immune function or in the primary response; and 15% are involved in other functions.

Example 24

5 200 known genes greater in old CR but not in young CR

Of the 685 genes and ESTs induced by CR in old mice, the identity of 200 are known (Table 8A); (Appendix I). Of these, 122 (61%) previously were shown to be induced by ST-CR in old mice. Thus, the majority are rapidly responsive to CR. Of the remaining 78 genes, approximately 12% are transcriptional regulators; 8% are growth
10 factor, cytokines or hormones; 13% are involved in signal transduction or cell cycle regulation; 11% are involved in embryogenesis and development; 10% are involved in cellular adhesion, or are components of the extracellular matrix or membrane; 4% are channels or ion pumps; 4% are involved in extracellular transport or secretion; 3% are involved in metabolism; 3% in DNA replication, repair or apoptosis; 2% in chromatin
15 structure; 3% in immune function or in the primary response; 2% in translation, splicing or RNA processing; 2% are cell surface receptors; and 23% are involved in other functions.

The proportion of genes involved in each functional category above are remarkably similar. Further, many of the genes induced by CR in young mice were
20 members of similar gene families or were structurally or functionally related to genes induced only in old mice. These similarities suggest that CR has highly homologous age-specific effects. It is less likely that the relative proportion of genes falling into each category, and the identity of these genes is an artifact of the probes present on the chip. Firstly, all of the results are statistically significant. Second, the genomic profiles
25 produced in several drug studies were strikingly different from those found here as to the identity of the genes affected, and their functional categories (data not shown). Together, these results indicate that CR has a robust, pervasive, and highly homologous effect in both young and old mice. It induced the expression of a substantial group of genes involved in a wide variety of cellular functions.

30 A commonly expressed view in the literature of CR and aging assumes tacitly or explicitly that CR acts by preventing deleterious, age-related changes in gene

expression. This view is shown schematically in Figure 9. This hypothesis assumes that prevention of age related changes in gene expression underlies the health- and life-span extending effects of CR. During aging, some genes become over expressed or under-expressed relative to their levels in young animals (lower and upper lines, Figure 9). Some of these deviations are assumed to be deleterious. Preferably, no changes would change with time, and aging would either not occur or occur more slowly (center line, Figure 9). In this view, CR should wholly or partially return over- or under-expressed genes to their youthful levels (arrows, Figure 9). Although the reasoning is circular, some have said that if CR changes the expression of a gene toward the center line in the figure, it restored youthful levels of expression. We have analyzed the results of the studies reported here to evaluate this hypothesis further.

Of the approximately 12,000 genes and ESTs examined, aging of control mice increased the expression of 257 genes and ESTs, and decreased expression of 191 genes and ESTs (Figure 9). Long-term CR wholly or partially, reversed or prevented 55 of the increases and 70 of the decreases. Short-term CR reversed 45 of the increases and 59 of the decreases in gene expression. Long-term and short-term CR both acted to reverse or prevent 23 of the increases and 41 of the decreases. Thus, long-term CR actually prevented the increased expression of only 32 genes and ESTs and the decreased expression of only 29 genes and ESTs. It is likely that the number of ESTs in each class overestimates the number of authentic genes in each category. First, the genes and ESTs which responded to CR in only 4 weeks are likely a subset of the genes and ESTs which respond acutely to CR. We have not yet examined longer times on the domain of genes responsive to acute CR. Some genes may be "slow changers" in response to acute CR. Second, we have found that many of the known genes present on these chips are redundant (e.g., multiple immunoglobulin genes of each class and T cell receptor genes, cloned chromosome breakpoints representing parts of two genes, uncharacterized chromosome regions, uninvestigated, unpublished cDNA sequences, etc.). For example, of the 23 genes and ESTs reduced to baseline expression levels only by LT-CR, 12 were known genes (Table 9). Of the 27 genes and ESTs which were decreased in expression by age and returned to baseline expression only by LT-CR, only 13 were from known genes (Table 10).

Of the 12 genes prevented from increasing with age by CR, few are involved in signal transduction. Rather, 6 are involved in immune system function, particularly in macrophage differentiation, proliferation, apoptosis, and activity. Of these, platelet-activating factor acetylhydrolase activity reduces plasma platelet activating factor mRNA levels. Platelet activating factor is a potent pro-inflammatory autacoid with diverse physiological and pathological actions. It does not seem likely that the return of these genes to baseline expression levels is due to a general reduction in inflammation, stress, or immune activity. In a previous study, we found that 61 immune system genes, including 6 primary response genes, and an additional 9 apoptotic genes were up regulated by both LT- and ST-CR in the liver of mice. Similar considerations apply to the other 6 genes in this group, and to the genes prevented from decreasing with age (Table 10). One can speculate about why reduction in the expression of the relatively few immune system specific, acute phase response genes and other genes listed in Table 9, or enhanced expression of the 13 immune system, and neuron or liver specific genes in Table 10 might be important in reducing the rate of aging. However, with few exceptions, very similar genes, and in some cases closely related family members of the genes in these lists are present in the group of 340 known genes induced by both LT- and ST-CR. Thus, it seems intuitively and statistically much more likely that the massive reprogramming of gene expression induced by CR (Tables 9 and 10) is responsible for the increase in life- and health-span induced by CR. The genes prevented from increasing and decreasing with age (Tables 9 and 10) seem much more likely to be the result, rather than the cause of these effects.

In summary, the studies presented here show that a major effect of CR is to massively (more than 10% of the genes and ESTs investigated) reprogram gene expression to a new pattern associated with slower aging and delayed onset of age-related diseases. This reprogramming includes age-independent induction of a relatively large group of genes and ESTs, as well as induction of smaller groups of genes age-dependently. Further, we found that age-related changes in gene expression are relatively rare. Even rarer are instances in which life-long CR prevents these changes. The rarity of such genes, and their identity suggest to us that they do not play a major role in the physiological effects of CR. The large and rapid response induced

Table 9. mRNAs increased by age and returned to control levels by LT-CR

<u>GenBank</u>	<u>Phenotype</u>
<u>Immune System</u>	
AF018268	Apoptosis inhibitory 6 (Api6); a member of macrophage scavenger receptor cysteine-rich domain superfamily; inhibits apoptosis of a variety of cell types; secreted specifically by macrophages
M13018	Cysteine rich intestinal protein (Crip); double zinc finger protein; expression changes with acute liver injury (cellular damage); may function in cell proliferation, differentiation or turnover; high expression in immune cells, low in liver
J04596	GRO1 oncogene (Grol); encodes a cytokine; mediator of inflammatory and immune responses; also called melanoma growth-stimulatory activity; cell cycle regulator; platelets
L20315	Macrophage expressed gene 1 (Mpeg1 or Mpg-1); increased when murine fetal liver hematopoietic progenitor cells induced to differentiate into macrophages; high levels in macrophages, moderate levels in certain myelomonocytic cell lines
U34277	Phospholipase A2 group VII, platelet-activating factor acetylhydrolase, plasma (Pla2g7); secreted phospholipase A2 which modifies the pro-inflammatory platelet-activating factor (PAF) to yield the biologically inactive lyso-PAF; regulates baseline circulating PAF levels and may be critical in resolving inflammation; high PAF is a predictor of heart disease; liver macrophages
L27990	Sjogren syndrome antigen A1 (Ssa1); Ro52; stress response gene; ribonucleoprotein; macrophages
<u>Ubiquitous</u>	
D86729	Heterogeneous nuclear ribonucleoprotein A1 (Hnrap1); ribonucleoprotein, RNA processing; early down-regulation of this gene contributes to the cytotoxicity of the topoisomerase inhibitors that induce DNA cleavage; ubiquitous
U50850	Retinoblastoma-like 2 (Rbl2); p130; transcriptional cell cycle repression through G1 phase (controls cyclin A, cdc 25G and cdc2 genes); tumor suppressor gene; expressed independently of retinoblastoma gene; expressed in embryo and ubiquitously in adult
U34042	Tolloid-like (Tll), an alternatively spliced product of the bone morphogenic protein-1 gene; metalloprotease purified from extracts capable of inducing ectopic bone formation; ubiquitous
<u>Liver Specific</u>	
U60438	Serum amyloid A protein isoform 2 (Saa2); encodes an acute-phase reactant serum protein; liver
<u>Not Reported in Liver</u>	
M27501	Protamine 2 (Prm2); compacting chromatin; expressed in postmitotic male germ cell during late stages of spermatogenesis
U52433	Tubby (Tub); mutation in the tub gene causes maturity-onset obesity; adipocyte fat storage increased by 5-6 fold, insulin resistance; mutant mice have retinal and cochlear degeneration; gene function unknown; brain, hypothalamus, cochlea, retina

Table 10 mRNAs decreased by age and returned to control levels by LT-CR

<u>GenBank</u>	<u>Phenotype</u>
<u>Immune System</u>	
M30903	B lymphocyte kinase (Blk); src-family protein tyrosine kinase; plays important role in B-cell development/activation and immune responses; B-lineage cells
U43384	Cytochrome b-245, beta polypeptide (Cybb, cytochrome b558); integral component of the microbicidal oxidase electron transport chain of phagocytic cells, respiratory burst oxidase; phagocytes
U10871	Mitogen activated protein kinase 14 (Mapk14); signal transduction, stimulate phosphorylation of transcription factors; major upstream activator of MAPKAP kinase 2; hematopoietic stem cells
Z22649	Myeloproliferative leukemia virus oncogene (Mpl); Member of hematopoietic cytokin receptor family, cell cycle regulator, induces proliferation and differentiation of hematopoietic cell lines; hematopoietic precursor cells, platelets and megakaryocytes
Y07521	Potassium voltage gated channel, Shaw-related subfamily member 1 (Kcnc1) potassium channels with properties of delayed rectifiers; nervous system, skeletal system, T lymphocytes
U87456	Flavin-containing monooxygenase 1 (Fmo1); xenobiotic metabolism; highly expressed in liver, lung, kidney, lower expressed in heart, spleen, testis, brain
U40189	Pancreatic polypeptide receptor 1 (Ppyr1), neuropeptide Y receptor, peptide Y receptor; G-protein-coupled receptor; liver, gastrointestinal tract, prostate, neurons endocrine cells
<u>Neuron Specific</u>	
U16297	Cytochrome b-561 (Cyb561); electron transfer protein unique to neuroendocrine secretory vesicles; vectorial transmembrane electron transport; brain
D50032	Trans-golgi network protein 2 (Ttgn2); integral membrane protein localized to the trans-Golgi network; involved in the budding of exocytic transport vesicles; brain neurons
<u>Liver Specific/Ubiquitous</u>	
D82019	Basigin (Bsg), CD147, neurothelin; membrane glycoprotein, immunoglobulin superfamily, homology to MHCs, acts as an adhesion molecule or a receptor, neuronal network formation and tumor progression; embryo, liver and other organs
L38990	Glucokinase (Gk), key glycolytic enzyme; liver
U50631	Heat-responsive protein 12 (Hrsp12); heat-responsive, phosphorylated protein sequence similarity to Hsp70; liver, kidney
U39818	Tuberous sclerosis 2 (Tsc2); mutationally inactivated in some families with tuberous sclerosis; encodes a large, membrane-associated GTPase activating protein (GAP tuberin); may have a key role in the regulation of cellular growth; ubiquitous

Gene expression in STZ-diabetic mice

Streptozotocin (STZ) induces diabetes. Mice receiving three treatments with STZ were diabetic for about 4 weeks. Diabetes reduces insulin levels to almost zero. CR has a similar effect in that it lowers insulin levels, although not as low as in STZ-treated animals. Also, while CR lengthens life span, STZ has the opposite effect and shortens life span.

Figure 10 shows pairwise comparison of global gene expression correlation coefficients for each possible mouse pair. The results indicate that hepatic gene expression is very different between young CR, young control and STZ-diabetic mice. Figure 11 presents a visual profile which shows that the pattern of gene expression in the three groups is dissimilar. In conclusion, lowering insulin in the pathological way found in serious diabetes is insufficient to produce the gene expression profile or the life-span effects observed with CR.

Example 26

Gene expression in aminoguanidine treated mice

Aminoguanidine is believed to retard aging by preventing cross-linking of protein initiated by the aldehyde form of glucose. However, mice fed aminoguanidine exhibited little or no effect on life span. However, a large effect on gene expression was observed (Figure 12). Gene expression for aminoguanidine-treated mice did not correlate with either old CR or old control. A visual representation of this finding is shown in Figure 13. In conclusion, although aminoguanidine has little effect on aging in mice, major differences in gene expression are observed. These effects are not like those of CR, and this is consistent with the absence of a strong effect on the life-span of mice.

Example 27

To determine whether certain interventions mimic calorie restriction in mice, the following groups of mice are prepared.

Group 1: Controls

Group 2: Troglitazone (synthetic proposed calorie restriction mimetic drug that lowers insulin levels in rats and mice, lowers blood pressure and triglycerides, inhibits free radicals, increases mitochondrial mass, and doesn't seem to change food intake in rodents): treatment starts at 10 months

5 Group 3: IGF-1 (natural proposed calorie restriction mimetic hormone that lowers both insulin and glucose levels and which may be directly involved in the basic mechanisms of aging; has rejuvenating effects on immune, muscular, and other systems): treatment starts at 12 months

10 Group 4: ALT-711 (or other AGE breaking agent: proposed calorie restriction mimetic that acts by reversing the effects of elevated glucose levels as they occur or after they occur, rather than by reducing glucose levels): treatment starts at 18 months.

Animals in all groups will receive the same, known amount of food throughout the study.

15 Troglitazone and IGF-1 doses will be chosen to set glucose and insulin levels in the range for young or preferably calorie-restricted animals. Glucose and insulin will be measured but not controlled in the control and ALT-711 groups. Troglitazone will be supplied at a dose of ~0.2% of the diet (standard for troglitazone studies for other purposes). Similarly, ALT-711 will be incorporated into the diet. A low (non-toxic) level of ALT-711 is used that will remain constant over time.

20 It is assumed that IGF-1 will be supplied by injection (3 times per week, minimum) unless a continuous delivery method can be arranged. The preferred dosage method is implantation of non-dividing IGF-1-secreting cells, to attain steady IGF-1 levels, and if possible, this will be done. If this is not possible, IGF-1 will be obtained as a gift from Genentech or another manufacturer. Other possible alternatives to
25 injection are: osmotic minipump; injection of IGF-1 into subcutaneous slow-release reservoirs; infusion by means of minipumps used by Celtrix; use of skin patches that allow slow-release to the body.

30 There will be 60 animals in each longevity-testing group (LTG). Each LTG will be accompanied by another set of, on average, 40 similarly-treated animals, which will be set aside for sacrifice to permit biochemical assays and histological documentation of the condition of the animals at fixed ages (sacrifice group, SG). In the case of the IGF-

1 and troglitazone groups, some animals will be earmarked for pilot dose-finding experiments in a manner that will allow the average SG size to remain at 40, as described below. The groups earmarked for dose-verification will be referred to as the pilot dose groups, or PDGs.

5 For troglitazone, about a 2-month supply of each of three troglitazone diets (containing 0.1%, 0.2%, or 0.3% troglitazone) will be initially ordered. The main 0.2% troglitazone dose will be tested on a small pilot mouse population before committing the troglitazone group proper to this dose. If 0.2% troglitazone is not found to yield the expected changes in circulating insulin after 2 weeks on the 0.2% troglitazone, the diet
10 will be changed to the more appropriate dose diet at that time and verified on a second small pilot mouse population.

Similarly, some animals will be used for IGF-1 injection pilot experiments to determine the proper starting dose.

At age 12 months: Sacrifice 3 animals/SG to obtain common baseline group of
15 12 animals to be compared to all subsequent results. This is the middle-aged universal control group. All subsequent data can be compared to the results for this pooled group.

At age 12.5 months: Begin the IGF-1 PDG with 7 mice given the best estimated dose of IGF-1. Sacrifice two weeks later for determination of insulin and glucose levels. Begin a verification/second trial dose of IGF-1 at 13 months, 1 week of age, and
20 sacrifice this second PDG at 13 months, 3 weeks of age. Assuming the assays for insulin and glucose can be completed in 1 week, this regimen will allow the final dose for the LTG to be determined prior to age 14 months. Similarly, at 12.5 months, place 7 mice on the 0.2% troglitazone diet. Two weeks later, sacrifice and assay for insulin and glucose. Begin adjusted-dose or verification dose group at 13 months, 1 week and
25 sacrifice after two weeks.

At age 14 months: Begin troglitazone and IGF-1 at the experimentally-determined or estimated optimal doses for each.

At age 15 months: Sacrifice six animals from the IGF-1 and troglitazone SGs for determinations of glucose, insulin, and all other endpoints involved in the study. If
30 necessary, adjust the IGF-1 dose again (both in the LTG and the untapped portion of the IGF-1 SG) and/or order diet with a modified troglitazone content. Sacrifice three

animals each from the SGs for the controls and the ALT-11 groups and pool to create a common group of six animals for comparison to the IGF-1 and troglitazone groups.

At age 18 months: same as at 15 months, but use 7 mice/SG for IGF-1 and troglitazone and 4 mice/SG for the control and for the ALT-711 group. Begin the ALT-711 groups on ALT-711 immediately after this sampling.

At around 27 months (~24-30 months): Sample all remaining surviving SG mice.

If the total initial numbers of mice in the sacrifice groups for treatments 1, 2, 3, and 4 are 30, 50, 50, and 30, respectively, then if there were no mortality in any of these groups, there would be 20 animals left in each SG at the time of final sampling. But if we assume that only 1/3 of this number will be alive, then about 7 animals will remain to be sampled at the final sample time, or about the minimum required for statistical significance. If the mean survival rate at 27 month is over 73%, the 27 month end point may be postponed to a greater age.

In addition to other biochemical markers, assays may include:

- heart and thymus volume and histology;

- autoantibody titer;

- T and B cell characteristics;

- protein or albumin concentration in bladder urine at sacrifice;

- molecular glycation indices;

- protein carbonyl content or other free radical/oxidation indices; and

- incidence of neoplasia, esp. of prostate and breast.

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.046	0.88	0.79	0.00	0.00	1.20	0.18	L34676	X11 protein gene; X11 protein Neurons binds amyloid precursor protein; receptor trafficking; +I543 may regulate the processing of amyloid precursor protein to the amyloid beta peptide	
0.006	0.95	0.27	0.28	0.27	1.23	0.11	U65418	Netrin-1; axon outgrowth- CNS promoting protein; guidance molecule; guides growing axons in development	
<0.001	1.10	0.02	0.00	0.00	1.09	0.19	X97817	Semaphorin F; involved in axonal guidance	Early embryogenesis
<0.001	1.02	0.01	0.04	0.08	1.06	0.09	L38580	Galanin; a neuro peptide; Released by hepatic nerves; CNS and enhances hepatic glucose peripheral organs including pituitary, production; present in hepatic pancreas, small and large intestine, adrenal gland, lung, tongue, testes, ovary-fallopian tubes, and uterus; not detectable in heart, liver, kidney, urinary bladder or skeletal muscle	
<0.001	1.14	0.16	0.02	0.03	1.14	0.16	X92122	UDP-galactose ceramide- galactosyl transferase; key enzyme in cerebroside and characterized sulfate biosynthesis; most glycosphingolipids; abundant in myelin	CNS and peripheral nervous system; poorly
<0.001	1.10	0.10	0.06	0.10	1.16	0.18	U56650	Neurexophilin 2 (Nxph-2); +I20 neuronal glycoprotein; binds to alpha-neurexins	
<0.001	0.99	0.22	0.04	0.06	1.04	0.06	L42340	Sodium channel 27	Brain; tissue distribution and protein poorly characterized
<0.001	1.16	0.27	0.03	0.06	1.11	0.11	X61449	Brain expressed anonymous cDNA	Brain; expression poorly characterized
<0.001	1.13	0.17	0.01	0.02	1.15	0.20	X92352	Bpx, strong homology to genes encoding nucleosome assembly proteins; poorly characterized	Brain; tissue distribution poorly characterized

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.001	1.29	0.29	0.03	0.05	1.22	0.22	X07215	PLP; proteolipid protein, main integral protein of the myelin	CNS
<0.001	1.17	0.19	0.03	0.06	1.16	0.25	Y12257	Glutamic acid decarboxylase 67 kD.	Brain, islets; isozyme of liver form
0.001	1.36	0.15	0.00	0.00	1.09	0.35	ET63017	Cadherin-8, adhesion molecule	MCad8 expression is restricted to particular subdivisions of the early central nervous system (CNS) and to the thymus
0.001	1.19	0.35	0.09	0.15	1.43	0.12	ET61642	Inward rectifier channel 2 (GIRK2)	potassium Neurons
0.001	1.18	0.25	0.11	0.19	1.16	0.21	X97281	K + channel beta-subunit, ion channel	Brain and Kidney
<0.001	1.06	0.07	0.10	0.12	1.08	0.08	Y09108	SNS-TTXi sodium channel, ion channel; small-diameter sensory neurons associated with unmyelinated axons express a tetrodotoxin-insensitive (TTXi) voltage-gated sodium channel (VGSC); may play an important role in the transmission of nociceptive information to the spinal cord	Brain
0.005	1.26	0.03	0.15	0.26	1.16	0.39	M30440	Potassium channel gene (MK2); Shaker subfamily	T cells; myelinating Schwann cells
0.018	1.78	0.50	0.40	0.46	1.10	0.21	S80989	NK-related homeobox gene (Nkx-5.2); cell type specification of neuronal cells	Developing CNS and ear in E13.5
0.011	1.00	0.21	0.50	0.24	1.22	0.13	X83577	K-glypican; cell surface heparin sulfate proteoglycan; role in regulating cell cycle progression during the transition of neural cells from proliferation to differentiation.	major sites are tubular epithelial cells in kidney and neuroepithelial cells in
0.044	1.12	0.26	0.61	0.27	1.32	0.28	U36757	Thrombin receptor transmembrane G-protein coupled receptor; activated by protease cleavage; thrombin is a	Blood, platelets, monocytes; endothelial cells; cardiomyocytes; serine neuronal and glial cells

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.004	1.02	0.02	0.53	0.17	1.02	0.12	M33467	serine protease generated by the activation of the blood coagulation cascade following vessel injury; thrombin acts as a mitogen, apoptosis inducer and regulator of inflammation Dilute lethal-20J; Class-V Adult germ line cells; early embryo; myosin; unique type of myosin oocyte during oogenesis; enriched in motor; role in vesicular brain; neurons; melanocytes membrane traffic through actin rich regions of the cytoplasm; transport endoplasmic reticulum vesicles in neurons and pigment granules in melanocytes	
0.000	1.31	0.06	0.00	0.00	0.98	0.06	ET62839	Immunoglobulin-like receptor B (PIRA1); activating receptor on murine B lymphocytes; dendritic cells; myeloid-lineage cells.	lymphocytes; dendritic cells, myeloid-lineage cells.
0.015	1.14	0.15	0.20	0.20	1.36	0.55	ET63156	Mouse homolog of the Disabled (Dab) MDab217; an adaptor molecule functioning in neural development.	Neuronal and hematopoietic cell protein; lines; growing nerves of embryonic mice
0.001	1.21	0.21	0.05	0.09	1.37	0.36	ET63385	Connexin30 (CX30); gap junction protein that forms transmembranous gap junction channels that connect adjacent cells	Brain; skin
0.043	1.44	0.43	0.33	0.56	1.40	0.38	ET63410	Semaphorin Hv; a novel member of semaphorin gene family; secreted glycoprotein involved in embryonic development	Developing lungs ; skeletal elements; neural tubes
<0.001	1.12	0.04	0.09	0.15	1.12	0.21	X53257	Neurotrophin-3 (NT-3) ; binds high affinity receptor trk C	Liver parenchymal cells and septum and cerebellum; thymus, heart, hippocampus; pancreas, spleen, kidney, adrenal gland

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.004	1.16	0.28	0.22	0.26	1.22	0.19	ET61665	Discs-large tumor suppressor homolog (dlgh1); important role in the localization and function of glutamate receptors and K(+) channels; member of the MAGUK (membrane associated guanylate kinase homologue) family of proteins	Localized to synapse; epithelial cells
0.001	1.05	0.20	0.16	0.27	1.32	0.15	ET63395	Axonemal dynein heavy chain (mdhc1); axonemal dyneins are molecular motors that drive the beating of cilia and flagella; heavy chains are main components of multisubunit motor ATPase complexes called dyneins	Brain, trachea, testis
0	1.21	0.17	0.00	0.00	0.95	0.09	ET63399	Axonemal dynein heavy chain (mdhc3); axonemal dyneins are molecular motors that drive the beating of cilia and flagella; heavy chains are main components of multisubunit motor ATPase complexes called dyneins	Brain, trachea, testis
0.013	1.09	0.08	0.21	0.36	1.30	0.42	ET63402	Axonemal dynein heavy chain (mdhc6); axonemal dyneins are molecular motors that drive the beating of cilia and flagella; heavy chains are main components of multisubunit motor ATPase complexes called dyneins	Brain, trachea, testis
0.002	1.07	0.09	0.24	0.21	1.14	0.23	ET63405	Axonemal dynein heavy chain (mdhc9); axonemal dyneins are molecular motors that drive the beating of cilia and flagella; heavy chains are main	Brain, trachea, testis

P	CR	std	CON	std	SW	std	GenBank	Description components of multisubunit motor ATPase complexes called dyneins	Location
0	1.02	0.08	0.05	0.09	1.14	0.08	Y08485	Synaptonemal complex protein 3; Testis; part of the lateral element of the synaptonemal complex; a meiosis-specific protein structure testis essential for synapsis of homologous chromosomes	synaptonemal complex 1 is also expressed in embryonic ovary, adult brain and
0.007	1.20	0.53	0.00	0.00	1.28	0.30	L28756	Gonadotropin-releasing hormone receptor; G-protein-coupled receptor; GnRH activates all four steroid-dependent tumor tissues	Anterior pituitary, brain and reproductive organs as well as many
0.003	1.18	0.24	0.29	0.23	1.09	0.10	Z46845	MAPK cascades by a PKC-dependent mechanism. Preproglucagon; peptide I and II; member of vasoactive intestinal peptide (VIP)/secretin/glucagon/GHRH family of neuropeptides	alpha cells, ileum + K41, pancreas and kidney, with other
<0.001	1.09	0.15	0.08	0.11	1.10	0.15	U66201	Fibroblast growth factor homologous factor 1 (FGF-1); nervous system development and function	expression in brain and skeletal muscle
<0.001	1.13	0.15	0.00	0.00	0.99	0.18	Z27088	Relaxin precursor (rlx); member of insulin gene remodeling of collagen uterine contractility	Brain, uterus, prostate gland, pancreas and kidney, with other
0.005	1.20	0.24	0.25	0.22	1.23	0.29	ET62740	Ankyrin-3 (Ank3); also ankyrin(G); implicated in clustering; essential for NaCh and neurofascin at initial segments and is required for physiological levels of sodium channel activity	Widely distributed, especially in epithelial tissues, muscle, and neuronal axons
0.007	1.37	0.08	0.34	0.35	1.05	0.25	U48397	Mercurial-insensitive channel 1 (mMIWC1);	water Brain, eye, lung, kidney, heart, allows muscle

water and small solutes to pass
Discs-large tumor suppressor Localized to synapse; epithelial cells
homologue (dlgh1) gene;
important role in the localization
and function of glutamate
receptors and K(+) channels;
member of the MAGUK
(membrane associated guanylate
kinase homologue ues) family of
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P	CR	std	CON	std	SW	std	GenBank	Description	Location
								signaling pathway; regulates insulin-like growth factor I expression and cell proliferation; modulates IL-6 action; regulates physiological functions in neurons; regulates transport of thyroxine into hepatocytes	
0	1.09	0.16	0.00	0.00	1.15	0.13	U60330	Ki antigen (PA28 gamma); cell proliferation; the interferon-distribution gamma (IFN-gamma)-inducible PA28 activator complex enhances the generation of class I binding peptides by altering the cleavage pattern of the proteasome	cell Liver, neurons, broad tissue
0	1.09	0.16	0.00	0.00	1.18	0.18	Z31663	Activin type IB receptor; limb development; expressed with the formation of the last phalanx of each digit	Embryo: brain, some ganglia, expressed vibrissae, lungs, body wall, stomach, ribs, limbs, shoulders, olfactory region, eye, tooth primordium, esophagus, mesonephros, dorsal root ganglia and is strongly expressed in the spinal cord.
0.001	1.02	0.35	0.00	0.00	1.31	0.16	U33535	Fibroblast growth factor 9 (FGF-9); autocrine and paracrine growth factor; prevents death in cultured motoneurons; plays a role in embryonic cell thrombopoietic activity the in vivo proliferation of megakaryocytes	Adult and developing CNS: neurons, astrocytes, oligodendrocytes, epithelial cells, brain, kidney, prostate (stromal cells); expressed in many areas including intermediate
NOT REPORT IN LIVER MUSCLE									
0.008	1.27	0.33	0.27	0.27	1.04	0.13	X04405	Myoglobin gene; small heme protein; binds gaseous ligands such as O2, CO and NO	Muscle
0.002	1.32	0.20	0.00	0.00	0.80	0.39	X92523	Skeletal muscle-specific (canp3); intracellular	calpain Skeletal muscle; differentially spliced variants in smooth muscles during

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.001	1.14	0.15	0.15	0.27	1.17	0.15	M92416	dependant cysteine proteinase; fetal period tissue specific myofibrogenesis, modifies ryanodine receptor Ca2+ release channel Fibroblast growth factor (Fgf6); Skeletal muscle Fgf6 is the only known member of the FGF family whose expression is restricted to the muscle cell lineage during development	
0.012	1.33	0.35	0.00	0.00	1.45	0.67	M14537	Nicotinic acetylcholine receptor beta subunit	Skeletal muscle
0.003	1.09	0.12	0.14	0.24	1.11	0.31	X55718	Nicotinic acetylcholine receptor e subunit; embryonic	Skeletal muscle
0.003	1.08	0.04	0.00	0.00	1.19	0.47	Z67747	ZT3 zinc finger factor	Skeletal, cardiac muscle, and spleen in adult
0.01	1.15	0.12	0.02	0.04	1.29	0.62	U37353	Protein phosphatase regulatory subunit	2A Skeletal and heart muscle
0.005	0.93	0.18	0.00	0.00	1.14	0.14	ET62103	Nebulin; a family of giant myofibrillar proteins	
0.002	1.18	0.18	0.24	0.21	1.14	0.22	ET62883	Skeletal muscle chloride channel	Skeletal muscle
0.023	1.45	0.58	0.00	0.00	1.16	0.61	ET63019	Skeletal muscle ryanodine receptor; calcium release channel	Skeletal muscle
0	1.02	0.07	0.00	0.00	1.27	0.23	ET62998	Dystrobrevin:postsynaptic protein; important in the formation and maintenance of the mammalian neuromuscular junctions.	
0.001	1.19	0.25	0.25	0.05	1.21	0.20	ET62865	Alpha 4 integrin; a leukocyte glycoprotein involved in both cell-extracellular matrix and cell-cell interaction	Skeletal muscle
0	0.98	0.21	0.00	0.00	1.25	0.05	U49393	Sarcoendoplasmic reticulum Ca2+ ATPase; ion pump	Skeletal, smooth, and cardiac muscle
0.005	1.20	0.24	0.25	0.22	1.23	0.29	ET62740	Ankyrin-3 (Ank3); also ankyrin(G); skeletal protein implicated in Na(+) neuronal axons	called Widely distributed, especially in muscle epithelial tissues, and muscle, and

P	CR	std	CON	std	SW	std	Description	Location
0.007	1.37	0.08	0.34	0.35	1.05	0.25	U48397 Mercurial-insensitive channel 1 (mMWC1); allows muscle water and small solutes to pass	water Brain, eye, lung, kidney, heart,
0.000	1.06	0.15	0.00	0.00	1.56	0.37	ET61090 Ryanodine receptor type-3; Skeletal and smooth muscle, CNS intracellular Ca2+ channels	
0.005	1.17	0.23	0.43	0.16	1.24	0.23	X83932 Ryanodine receptor type 1 (RYR1 Skeletal muscle gene); intracellular calcium channel	
0.004	1.25	0.48	0.00	0.00	1.28	0.24	X80417 MB-IRK2 (second class of inward Heart, kidney, and skeletal muscle rectifier potassium channels); ion channel	

VASCULAR SMOOTH MUSCLE

0	1.00	0.15	0.02	0.03	1.15	0.10	U58367 Neuropeptide Y receptor Neurons, vascular smooth muscle Y5/Y6/Y2b (referred to as both cells Y5 and Y2b, has now been designated as Y6 in literature); important regulator of energy balance in mammals through its orexigenic, antithermogenic, and insulin secretagogue actions; expressed abundantly in the central nervous system; NPY receptors mediate a variety of physiological responses including feeding and vasoconstriction	
0.021	1.40	0.24	0.00	0.00	0.79	0.71	J03293 Phosphorylase kinase, gamma Heart, skeletal and cardiac muscle subunit; phosphorylates and (not in liver and the liver gamma activates glycogen subunit does not cross-hybridize with phosphorylase, the enzyme that the skeletal muscle gamma subunit initiates the catabolism of cDNA) glycogen in skeletal muscle	

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.044	1.12	0.26	0.61	0.27	1.32	0.28	U36757	Thrombin receptor Transmembrane coupled receptor; activated by neuronal and glial cells serine protease cleavage; thrombin is a serine protease generated by the activation of the blood coagulation cascade following vessel injury; thrombin acts as a mitogen and apoptosis inducer	(PAR-1); Blood, platelets, monocytes; G-protein endothelial cells; cardiomyocytes;
0.000	1.06	0.15	0.00	0.00	1.56	0.37	ET61090	Ryanodine receptor intracellular Ca2+ channels	type-3; Skeletal and smooth muscle, CNS
NOT REPORTED IN LIVER: SIGNAL TRANSDUCTION									
0.013	0.77	0.51	0.00	0.00	1.10	0.15	L12460	Mouse cyclic GMP-dependent protein kinase II; signal transduction	Brain, kidney, small intestine, colon
0.000	0.96	0.15	0.00	0.00	1.48	0.12	Y00850	Mouse Kruppel-like gene (MKr2); differentiation and/or phenotypic neurons of adults maintenance of neurons	Restricted to central and peripheral
0.022	1.13	0.08	0.40	0.24	1.04	0.35	Z23143	Activin receptor-like receptors for morphogenic proteins; serine-threonine kinase	kinase-6; Developing mesenchyme, muscle, vessels, CNS, ear, eye, epithelium
0.044	1.26	0.38	0.44	0.39	1.12	0.12	X66983	Rck gene; protein kinase	Photoreceptors, olfactory receptors, respiratory and choroid plexus epithelial cells, germ cells
0.048	1.79	1.06	0.00	0.00	1.18	0.54	U33005	Tbc1; domains homologous to Not tre-2 oncogene and yeast mitosis regulators BUB2 and cdc16; kidney nuclear localization	well-characterized; cells, testis and
<0.001	0.98	0.18	0.03	0.03	1.08	0.11	Y12293	LUN transcription forkhead domain identical to the HFH8 gene; C-terminal region not well characterized similar to the HFH8 gene	factor; Lung bronchiolar epithelium and type
<0.001	1.18	0.20	0.00	0.00	1.04	0.15	U48721	Zinc finger protein 60 (ZFP60); Kruppel associated boxes DNA-binding transcription factor (Emb); class VI POU domain	Expressed transiently during in vitro muscle differentiation
0.003	1.43	0.41	0.07	0.12	1.33	0.34	D13801		tissue distribution not well characterized

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.026	1.07	0.69	0.00	0.00	1.06	0.09	X63963	Paired box protein transcription factor 3	(Pax-6); Development of eye and CNS
<0.001	1.07	0.02	0.00	0.00	1.07	0.19	U76208	Neurogenin 3 transcription factor; related bHLH protein	(ngn3); CNS and early precursors of neuroD-pancreatic endocrine cells (embryogenesis)
0.003	1.15	0.31	0.07	0.12	1.28	0.32	U17252	Metabotropic glutamate receptor 8; G-protein coupled	CNS, glial cells; retina and olfactory bulb; stellate/basket cells
<0.001	1.02	0.02	0.04	0.06	1.06	0.17	U14420	GABA-benzodiazepine receptor beta-3 subunit; link binding of GABA (gamma-aminobutyric acid) to inhibitory chloride flux	receptor CNS
<0.001	1.11	0.22	0.09	0.16	1.07	0.07	X66118	Glutamate receptor subunit Brain GluR5-2c.	subunit Brain
0.001	1.11	0.33	0.06	0.10	1.05	0.04	Z14224	5HT1E beta serotonin receptor; protein-coupled receptor	G Brain; tissue distribution not well characterized
0.001	1.21	0.29	0.02	0.03	1.26	0.29	X79082	MDK1 (mouse developmental kinase 1); member of receptor tyrosine kinase family	Brain, testes and spleen
<0.001	1.20	0.22	0.01	0.01	1.30	0.27	Z48757	Intestinal tyrosine kinase; tyrosine kinase	protein Mammary gland and intestine
0.001	1.11	0.16	0.00	0.00	1.19	0.37	X58287	MR-PTPmu; receptor-like tyrosine phosphatase	protein Lung, brain, heart
<0.001	1.11	0.17	0.00	0.00	1.14	0.14	M61000	Bombesin/gastrin-releasing peptide receptor; member of the G protein-coupled receptor family	Fibroblasts
0.001	1.20	0.18	0.09	0.16	1.00	0.25	ET61461	G-protein coupled poorly characterized	receptor; Unknown
0.009	1.14	0.10	0.50	0.18	0.96	0.20	ET63226	Nude gene (Whn) winged transcription factor modulates growth production by differentiating epithelial cells including keratinocytes; also controls development of the immune system in thymus.	In adult thymus and skin; embryonic family; nails, nasal passages, tongue, palate factor and teeth

NOT REPORTED IN LIVER: HORMONE / GROWTH FACTOR

0.007	1.09	0.08	0.39	0.27	1.11	0.20	M22740	Thyrotropin beta-subunit (TSH- Pituitary
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P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.007	1.00	0.11	0.39	0.27	1.11	0.12	U12932	Follicle stimulating hormone beta subunit (FSH-beta, gonadotropin); stimulates development of follicle and spermatogenesis	the anterior pituitary
0.004	0.91	0.33	0.21	0.34	1.46	0.09	U25145	Luteinizing hormone beta subunit; regulation of reproduction	Gonadotropes of the anterior pituitary
NOT REPORTED IN LIVER EMBRYONIC DIFFERENTIATION TRANSCRIPTION FACTORS									
0.001	1.06	0.09	0.00	0.00	0.98	0.33	X51683	T gene (Brachyury gene); family; sequence specific binding protein that functions as morphogenesis a transcription activator; required for morphogenesis of mesoderm-derived structures, control of gastrulation; development of the heart; perhaps limb formation	embryogenesis; heart and limb
0.001	1.09	0.10	0.00	0.00	1.17	0.37	Z15103	Mox-1; homeobox gene; of epithelial-mesenchymal transformation	marker Early embryogenesis; mesodermal patterning in mouse embryos
0.001	1.08	0.08	0.22	0.18	0.91	0.21	X86368	Fkh-2; a forkhead/winged helix transcription factor	Numerous tissues of embryo, including paraxial mesoderm, somites, branchial arches, vibrissae, central nervous system and kidney
<0.001	1.10	0.02	0.00	0.00	1.09	0.19	X97817	Semaphorin F; involved in guidance	axonal Early embryogenesis
0.018	1.78	0.50	0.40	0.46	1.10	0.21	S80989	NK-related homeobox gene (Nkx-5.2); cell type specification of neuronal cells	Developing CNS and ear in E13.5
0.011	1.00	0.21	0.50	0.24	1.22	0.13	X83577	K-glypican; cell surface sulfate proteoglycan; role in regulating cell progression during the transition of neural cells from proliferation to differentiation.	heparin In embryo major sites are tubular cells in kidney and neuroepithelial cells in brain; neurons
0	1.03	0.03	0.11	0.10	1.08	0.21	M34094	Retinoic acid-responsive (MK); growth factor	protein Mid-gestation mouse embryogenesis; not reported in normal adult liver

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0	1.11	0.09	0.00	0.00	1.03	0.15	M93128	Homeobox transcription factor	Embryo
0	1.04	0.15	0.13	0.12	1.16	0.10	X16510	Hox 3.3; homeobox transcription factor; embryogenesis; haematopoiesis	Spleen, bone marrow
0	1.09	0.16	0.00	0.00	1.18	0.18	Z31663	Activin type IB receptor; expressed with the formation of the last phalanx of each digit	Embryo: brain, some ganglia, expressed vibrissae, lungs, body wall, stomach, ribs, limbs, shoulders, olfactory region, eye, tooth primordium, esophagus, mesonephros, dorsal root ganglia and is strongly expressed in the spinal cord.
0	0.99	0.06	0.12	0.20	1.10	0.13	D78175	Atrial natriuretic clearance receptor (ANP-CR or NPRC); modulates availability of natriuretic peptides at target organs; activation of G protein-coupled signaling system; endothelial permeability; may modulate angiogenesis by inhibition of vascular endothelial cell growth factor; modulates activity of mitogen-activated protein kinase (MAPK, regulation of cell proliferation)	peptide Epithelial and endothelial cells; lung (smooth muscle cells), heart (aortic smooth muscle cells), placenta

NOT REPORTED IN LIVER: Other

0.000	1.43	0.07	0.18	0.21	1.05	0.22	Z38118	Synaptonemal complex protein 1 (SCP1); pairing of chromosomes during meiosis	Testis
0.003	0.86	0.29	0.11	0.19	1.21	0.19	U61085	Thiazide-sensitive sodium chloride cotransporter; transmembrane protein	and Kidney
0.024	1.20	0.36	0.34	0.30	1.46	0.44	X95226	Dystrobrevin; formation and maintenance of mammalian	CNS

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.000	1.38	0.32	0.00	0.00	0.96	0.10	U73915	neuromuscular junction Membrane metalloendopeptidase homologue (Pex); mineralization of extracellular matrix by osteoclasts	Kidney, bone Mammary glands
0.011	1.10	0.10	0.35	0.38	1.13	0.13	M10114	Kappa-casein; milk protein	
0.037	1.32	0.29	0.14	0.24	0.90	0.63	X99251	Repetin; similar to intermediate filament-associated proteins profilaggrin and trichohyalin; expression during late epidermal differentiation	Epithelia of forestomach and tongue
0.006	1.26	0.18	0.30	0.22	0.98	0.29	U66204	Fibroblast growth factor CNS homologous factor 4 (FHF-4); involved in nervous system development and function	
0.004	1.06	0.10	0.36	0.27	1.10	0.10	M36516	Zinc finger proteins (mkr3,4,5)	Whole embryo, testes in adult
0.034	0.96	0.30	0.32	0.40	1.14	0.12	X86000	N-glycan alpha 2,8- sialyltransferase (STSia IV)	Lung, heart, spleen, brain
0.025	1.21	0.11	0.40	0.36	1.12	0.33	M25513	Rod transducin alpha subunit (Tr- alpha); couples photolysis of heart rhodopsin to activation of cGMP phosphodiesterase; visual signal cascade	Retina, not reported in liver, kidney,
0.008	1.18	0.51	0.23	0.40	1.82	0.25	X12875	Neural cell adhesion molecule L1 (N-CAM L1); involved in Ca2+ independent neural adhesion	Nerve cells
0.049	1.44	0.41	0.49	0.38	1.12	0.30	Y00500	Glandular kallikrein mGK-5; serine protease	Salivary glands; possible crosshybridization with liver kallikreins
0.030	1.18	0.07	0.29	0.45	0.85	0.25	X63100	Connexin45; gap junction protein; ion exchange channels	Lung, brain, heart, intestine; embryonic brain, skin, and kidney
0.036	1.30	0.18	0.41	0.45	1.06	0.28	ET62673	Hyaluronan synthase 3; polymerizes hyaluron, (extracellular) glycosaminoglycan; can be hallmark of tissue remodeling; reduces cell motility; hyaluron found throughout the	Eyes, kidney, chondrocytes

P	CR	std	CON	std	SW	std	GenBank	Description	Location
								extracellular matrix, especially in soft connective tissue	
0.017	1.81	0.92	0.00	0.00	1.12	0.11	D87471	Actin capping protein; germ cell Haploid germ cells of testis gene 3 (gsg3); homologue of somatic cell type actin capping protein alpha (ACP alpha)	
0.019	1.16	0.14	0.48	0.30	1.26	0.29	J04847	PL10; ATP-dependent RNA Testis (not reported in liver) helicase; suggested role in spermatogenesis; protein homologous to eIF-4A	
<0.001	1.09	0.14	0.01	0.02	1.19	0.29	Z46299	Sp17 gene for sperm specific protein; calmodulin binding	Mammalian testis; sperm-specific
<0.001	1.05	0.05	0.14	0.23	1.08	0.09	X72697	Meiosis-specific transcriptional activator function? of nuclei	Testis; lymphoid cell lineages; nuclei of spermatocytes, early in the prophase of the first meiotic division, and later becomes concentrated in the XY nuclear subregion
<0.001	1.20	0.18	0.02	0.02	1.07	0.26	M19413	Testicular alpha tubulin	Testis
<0.001	1.17	0.20	0.08	0.14	1.01	0.01	X96606	Ott, mouse X-linked multigene family	Expressed during meiosis
0.002	1.14	0.31	0.13	0.22	1.23	0.10	D13664	Osteoblast specific factor (OSF-2); extracellular matrix?	2 Osteoblastic cells
0.006	1.33	0.43	0.09	0.15	1.40	0.39	X15830	Neuroendocrine protein 7B2; secretory protein present in serum; proteolytic conversion and activation of convertases 2 in the endoplasmic reticulum	Widely distributed neuroendocrine cells; neurons, endocrine cells; pituitary, cells producing insulin and glucagon; melanosomes
0.440	1.10	0.80	0.53	0.59	1.27	0.67	D38162	Alpha1(XI) collagen	Embryo cartilaginous tissue, brain, structural integrity; essential for heart, tongue, intestine, and otic normal cartilage development vesicles
0.002	1.01	0.03	0.43	0.37	1.56	0.04	M35732	Seminal vesicle secretory protein IV (SVS IV); major secretory protein of seminal vesicles; regulation of the immune response, blood coagulation;	Seminal vesicles

P	CR	std	CON	std	SW	std	GenBank	Description	reaction;	Location
0.043	1.87	0.72	0.00	0.00	0.97	0.95	X05260	Y chromosome RNA transcript Testis (reported not present in adult expressed in testis (pY353/B); liver) protein product uncharacterized; sex determination factor?		
0.046	2.86	0.65	0.00	0.00	1.46	1.74	U96701	Intracellular serine proteinase Predominantly in testis inhibitor (mBM2A); serine proteinase inhibitors (serpins) are regulators of extracellular proteolysis		
0.019	1.42	0.39	0.58	0.06	1.11	0.20	ET63122	Beta-Tectorin; extracellular matrix Inner ear; expressed by cells in and surrounding the mechanosensory epithelia in embryo and adult		
0.005	1.00	0.05	0.25	0.31	1.15	0.21	X04724	Preproinsulin gene II		Pancreas and islets
0.004	1.21	0.39	0.06	0.11	1.63	0.46	X04725	Preproinsulin gene I		Pancreas and islets
0.002	1.51	0.44	0.00	0.00	1.20	0.32	ET63205	Odorant binding protein Ib		Nasal epithelium.
0	1.18	0.33	0.00	0.00	1.51	0.21	ET63408	Capping protein beta 3 subunit; a Spermiogenesis novel isoform of actin-binding protein; a component of the cytoskeletal calyx of the mammalian sperm head.		
0.045	1.24	0.21	0.00	0.00	0.93	0.81	X58169	T-complex responder (Tcp-10); Male germ line Tcp-10 gene has been established as a molecular candidate for the T complex responder locus which plays a central role in the transmission ratio distortion phenotype expressed by males heterozygous for a T haplotype..		
0.011	1.45	0.81	0.00	0.00	1.72	0.25	ET61364	Meprin beta subunit isoform Kidney, intestine, not reported in (Mep-1beta); meprins are liver membrane-bound oligomeric metalloendopeptidases, contain alpha and/or beta subunit		
0.008	1.19	0.16	0.22	0.19	1.37	0.47	ET62832	Perforatorial protein (PERF 15); a Testis		

P	CR	std	CON	std	SW	std	GenBank	Description	Location
								novel testicular protein; sequence similarities to a family of lipid binding proteins; major component of the rat sperm perinuclear theca.	
0.016	1.29	0.33	0.24	0.26	1.17	0.40	ET62968	Odorant receptor 23 (OR23)	Olfactory and testicular cells
0.003	0.94	0.45	0.02	0.04	1.21	0.02	ET63528	A-myb; a conserved member of the Myb proto-oncogene family; encodes a sequence-specific DNA binding protein (A-Myb) that binds to and transactivates promoters containing myb-binding sites	Abundant expression in testis (germ cell differentiation); low level expression in ovary, spleen (B lymphocytes) and brain; CNS in embryonic
0.005	1.44	0.46	0.00	0.00	1.14	0.39	ET63177	Pax-4; a paired-box transcription factor that plays an important role in the development of pancreatic beta/delta cells; role in endocrine cell development	Pancreatic islet endocrine progenitor cells
0.001	1.06	0.22	0.04	0.07	1.37	0.33	M20567	Heat-shock-like protein (HSP70.2); not induced by heat shock; developmentally regulated in spermatogenic cells; critical role in spermatogenesis	70-2 Male germ cells
0.001	1.30	0.05	0.00	0.00	1.10	0.38	ET61399	G protein alpha olfactory subunit; sensory transduction	Olfactory epithelium
0.015	1.07	0.08	0.09	0.15	1.16	0.57	L28819	Involucrin; a glycine-serine-cysteine-rich protein expressed late in differentiation of granular layers in normal epidermis	Epidermis
0.005	1.45	0.52	0.05	0.09	1.17	0.26	ET62336	DNA ligase III-beta; DNA ligase III Alpha exists as two distinct isoforms denoted alpha and beta	DNA ligase III Alpha is expressed in most tissues; DNA ligase III-beta is expressed in testes and during spermatogenesis
0	0.95	0.18	0.07	0.12	1.13	0.11	D49438	25-hydroxyvitamin D3 hydroxylase; metabolism and regulation of vitamin D3	24- Kidney and intestine.
0.011	1.27	0.28	0.00	0.00	1.22	0.59	M26940	Beta-casein gene	Mammary glands

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.001	1.03	0.29	0.05	0.05	1.12	0.10	V00740	Epsilon-casein	Mammary glands
0	1.01	0.08	0.02	0.04	1.07	0.07	V00428	Lysozyme; signaling molecule for mast cells which respond with histamine secretion	Macrophages, paneth cells (located in duodenal crypts)

BLOOD, NOT IgG

0.037	1.24	0.26	0.45	0.42	1.09	0.16	U86405	Amphiphysin II; endocytosis and signal transduction (recycling synaptic vesicle components)	Macrophages, neurons, germ cells,
0.013	1.02	0.02	0.11	0.19	0.94	0.44	U69136	T1-cadherin, calcium-binding membrane glycoprotein acting as cell adhesion molecule (CAMs).	Thymocytes
0.006	1.31	0.40	0.16	0.20	1.32	0.30	X53176	Integrin alpha-4; cell adhesion	Lymphocytes
<0.001	1.27	0.15	0.03	0.05	1.14	0.24	X91043	Erythrocyte band 7 integral membrane protein; protein 7.2b; liver stomatin	Spleen, lung, testis, not reported in
<0.001	1.06	0.06	0.14	0.12	1.12	0.15	X15592	CTLA-2-beta; homologue to T cells cysteine protease proregion	
0.002	1.11	0.15	0.15	0.26	1.12	0.20	X97227	Cell surface glycoprotein CD53; pan-leukocyte antigen; cell membrane glycoprotein	Thymocytes
<0.001	1.10	0.20	0.03	0.05	1.27	0.19	U43384	Gp91phox (Cybb); phagocyte cytochrome b558; heterodimer comprised of gp91phox and p22phox; a flavocytochrome that mediates the transfer of electrons from NADPH to molecular oxygen in the respiratory burst oxidase	Phagocyte
0.005	1.26	0.03	0.15	0.26	1.16	0.39	M30440	Potassium channel gene (MK2); shaker subfamily	T cells; myelinating Schwann cells
0.002	0.99	0.29	0.00	0.00	1.35	0.35	X52991	Homologue of the rat T cell differentiation marker RT6; cell-cell signaling	Cytotoxic T lymphocytes
0.000	1.37	0.11	0.00	0.00	0.97	0.11	X14092	MCSP-1 CTL serine protease 1; may play a role in cytolysis	T lymphocytes
0.033	1.36	0.33	0.29	0.50	1.07	0.30	U04269	Interleukin-1 beta converting lymphocyte activation	Monocytes and macrophages

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.015	1.47	0.47	0.24	0.41	1.07	0.06	L16928	enzyme (ICE); may mediate endotoxin-induced effect of decreased hepatocellular bile salt uptake; IL-1DOWN in CR	
0.027	1.20	0.13	0.24	0.34	0.94	0.44	ET62844	Differentiation antigen (CD22); B cells mediates B cell interactions with endothelial cells	
0.046	1.31	0.39	0.31	0.50	0.98	0.18	U49866	Immunoglobulin-like receptor B lymphocytes, myeloid lineage cells PIRA6 (12M1); appears to activate immunoglobulin-related receptor	
0.003	1.07	0.07	0.38	0.21	1.05	0.17	X04123	Class I recognizing receptors Subpopulation of natural killer cell involved in ability of F1 hybrid mice to reject parental H-2d bone marrow cell grafts	Earliest stage B and T cells
0.007	1.53	0.51	0.00	0.00	1.51	0.54	U25691	Terminal deoxynucleotidyltransferase; template-independent DNA polymerase; VDJ assembly; recombination	
0.005	1.07	0.45	0.00	0.00	1.93	0.62	M23501	Lymphocyte specific helicase; T and B cells at both the immature putative role in replication, repair, and mature stage; not in heart, liver, recombination and transcription lung, muscle, brain or kidney	
0.007	1.08	0.13	0.20	0.34	1.11	0.23	ET61471	P500/TCA3; SIS-epsilon; small, T cells, myeloid and lymphoid cells secreted, and inducible protein; expressed more abundantly in activated mouse helper T cells than by resting T cells	
0.001	1.10	0.31	0.00	0.00	1.41	0.33	M55617	Mast cell protease 7 (mMCP-7); Mast cells mouse mast cell tryptase 2; released when mast cells are activated	Peritoneal and most connective tissue
0.038	1.06	0.10	0.30	0.53	1.15	0.21	X51468	Mast cell protease-4	
BLOOD: HORMONE / CYTOKINE / CHEMOKINE / SIGNAL TRANSDUCTION / RECEPTOR									
								Preprosomatostatin; peptide cleaved to release	precursor Macrophages; nervous system

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.044	1.53	0.46	0.17	0.30	1.03	0.69	M16762	somatostatin which regulates T cell IFN-gamma production	Interleukin 2 (IL-2); stimulates Helper T cells proliferation of activated T lymphocytes
0.014	1.06	0.06	0.54	0.18	1.30	0.34	X54542	Interleukin-6; promotes B cell maturation to Ig-secreting cells; helps activate T cells	Some helper T cells and macrophages
0.004	1.00	0.08	0.22	0.38	1.40	0.24	X07962	Interleukin 7 (IL-7); growth factor	B cell progenitors
0.000	1.52	0.10	0.00	0.00	0.97	0.19	U28404	Macrophage inflammatory protein-1 alpha receptor; mediates growth inhibitory effects of the chemokine	MIP-1alpha RL2 in liver and spleen
0.001	1.38	0.28	0.12	0.21	1.00	0.17	X53798	Macrophage inflammatory protein-2 (MIP2); small inducible cytokine subfamily member	Inflammatory Macrophages
<0.001	0.99	0.11	0.07	0.13	1.25	0.22	ET62976	Macrophage inflammatory protein receptor 1-alpha 2; mobilization of intercellular calcium; leucocyte chemoattractant	Thymus, heart, spleen, and liver; to receptor 1-alpha 2; Induces lesser extent in the lung and brain
0.015	1.31	0.23	0.44	0.35	1.04	0.13	V00755	Interferon beta (type 1); growth factor; T helper cell differentiation factor; antiviral; modulates immune responses to foreign and self-antigens	Ubiquitous T cells
<0.001	1.21	0.19	0.11	0.19	1.10	0.11	V00756	Interferon beta (type 2)	T cells
0.015	1.31	0.52	0.00	0.00	1.19	0.50	M26271	Interleukin 2 receptor; receptor	cytokine T cells
0.016	1.47	0.65	0.14	0.21	1.08	0.10	M35684	Complement receptor type 2	Late pre-B cells
0.010	1.22	0.69	0.05	0.09	2.15	0.64	L41495	Protein-serine/threonine kinase (pim-2); cell proliferation; expressed in mitogenically stimulated (cytokines) hematopoietic cells; evokes long-term potentiation in hippocampus	Blood, epithelial and CNS embryonic

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.002	2.00	0.36	0.00	0.00	1.17	0.55	ET61263	Cytosolic tyrosine protein kinase SYK; signal transduction	Lymphopoiesis; haematopoietic cells, platelets, macrophages and neutrophils
<0.001	1.07	0.11	0.02	0.03	1.11	0.10	X58995	Calmodulin-dependent protein T cells kinase IV; multifunctional, serine- threonine protein kinase	
0.002	1.22	0.42	0.00	0.00	1.14	0.13	D30743	Wee1 kinase; inhibits entry into Lymphocytes mitosis by phosphorylation of the	
0.044	1.12	0.26	0.61	0.27	1.32	0.28	U36757	Cdc2 kinase Thrombin receptor (PAR-1); Blood, transmembrane G-protein coupled endothelial cells; platelets, monocytes; receptor; activated by serine neuronal and glial cells protease cleavage; thrombin is a serine protease generated by the activation of the blood coagulation cascade following vessel injury; thrombin acts as a mitogen and apoptosis inducer.	
<0.001	1.15	0.13	0.00	0.00	1.05	0.17	U36575	T cell transcription factor NFAT1 T cells isoform B	
<0.001	1.02	0.16	0.00	0.00	1.13	0.15	Z11664	Son of sevenless 2; Ras-specific T cells exchange factors	
0.002	1.18	0.17	0.16	0.27	1.22	0.25	Z11574	Son of sevenless 1; Ras-specific T cells exchange factors	
0.026	0.82	0.47	0.19	0.34	1.43	0.39	M36654	Homeobox gene 2.6 (Hox-2.6) Whole embryo; in adult: blood cells, transcription factor; embryonic stem cells and low levels in somatic development; haematopoiesis and spermatogenic cells	
0.034	1.30	0.84	0.00	0.00	1.22	0.24	U10092	Ly-49F-GE antigen; NK cell NK cells surface molecule; determinant of IL-2-activated NK cell specificity; inhibitory receptor for interaction with MHC class I	
0.003	1.15	0.23	0.27	0.12	1.17	0.24	L43567	Antigen, B cell receptor	Blood
0.007	1.08	0.13	0.20	0.34	1.11	0.23	ET61471	Mast cell protease 7 (mMCP-7), Mast cells mast cell tryptase 2; released when mast cells are activated	
0	1.14	0.05	0.00	0.00	0.96	0.26	ET61424	Protein-tyrosine phosphatase	Hematopoietic tissues

epsilon precursor; the protein tyrosine phosphatase epsilon (PTPepsilon) gene gives rise to two proteins: a transmembranal, receptor-like form and a cytoplasmic, non-receptor form

CC Chemokine Receptor-4; Thymus, T cells, and monocytes

ET62920

1.63 0.18

0.00

0.57

1.31

0.003

0.00

0.044

0.004

Thrombin receptor (PAR-1); Blood, platelets, monocytes; transmembrane G-protein coupled endothelial cells; cardiomyocytes; receptor; activated by serine neuronal and glial cells protease cleavage; thrombin is a serine protease generated by the activation of the blood coagulation cascade following vessel injury; Thrombin acts as a mitogen and apoptosis inducer. Immunoglobulin-like receptor B lymphocytes; dendritic cells, and myeloid-lineage cells

Hox 3.3; homeobox transcription Spleen, bone marrow factor; embryogenesis;

X16510

1.16 0.10

0.12

0.15

1.04

0

0.13

0.04

0.04

haematopoiesis

U36757

1.32 0.28

0.27

0.26

1.12

0.044

0.04

0.04

0.04

Whole developing embryo; blood; bone marrow cells; natural killer cells

BLOOD TRANSCRIPTION FACTOR

X06762

1.77 0.83

0.31

0.18

1.07

0.029

0.02

0.02

0.02

U29513

1.11 0.11

0.27

0.46

1.10

0.012

0.01

0.01

0.01

transcriptional repressor; associates with RB in vitro

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.001	1.03	0.03	0.21	0.14	1.04	0.25	ET62444	Sox4; transcription factor in the Thymus, bone marrow, and gonads Sox gene family with separable DNA-binding and transactivation domains	

PRIMARY RESPONSE GENES - LIVER

0.002	0.91	0.20	0.22	0.20	1.15	0.14	L24118	TNF-inducible; primary response gene B94	Liver (during development) and monocytes (postnatally)
0.002	1.19	0.32	0.00	0.00	1.27	0.33	X83601	PTX3, entraxins; include reactive protein (CRP) and serum amyloid P component (SAP) which are prototypic acute phase reactants that serve as indicators of inflammatory reactions.	C Liver, skeletal muscle and heart
0.002	1.09	0.31	0.00	0.00	1.39	0.39	M31419	Interferon-activatable gene (204); Nucleoimediates immunomodulatory and cell growth-regulatory activities of interferons; increased up to 75-fold by alpha-interferon treatment	

PRIMARY RESPONSE GENES - OTHER TISSUES

<0.001	1.11	0.17	0.09	0.15	1.00	0.17	D13695	ST2L, primary response gene; specifically induced by growth stimulation; highly similar to IL1 receptor type 1	T cells
0.005	1.28	0.46	0.00	0.00	1.40	0.39	U34245	Fos-related antigen-1 (Fra-1)	Spleen
<0.001	1.04	0.04	0.00	0.00	1.14	0.21	Y08026	Immunity associated protein inducible by malaria	38; Spleen
0.001	1.35	0.36	0.00	0.01	1.23	0.20	M81077	TAL2	T cells
<0.001	1.03	0.14	0.00	0.00	1.10	0.09	U19463	Zinc finger protein A20; activated by T cell acute lymphoblastic leukemia; helix-loop-helix DNA binding protein	Lymphocytes
0.1	1.27	0.24	0.00	0.00	1.40	1.23	L15435	4-1BB ligand, inflammatory response; member of the TNF	T cells

P	CR	std	CON	std	SW	std	GenBank	Description	Location
<0.001	1.18	0.18	0.00	0.00	1.03	0.16	M88242	Glucocorticoid-regulated inflammatory cyclooxygenase; prostaglandin G/H synthase, putative mediator of inflammation; mRNA and protein rise dramatically in response to growth factors, cytokines, and oncogene activation; suppressed by glucocorticoid hormone	Fibroblasts and human monocytes
<0.001	1.07	0.12	0.00	0.00	1.16	0.09	L38281	Immune-responsive gene 1 (Irg1); Macrophages activated by bacterial LPS treatment	
0.001	1.15	0.32	0.02	0.03	1.31	0.28	K02785	Gene induced by PDGF with Unknown some homology to c-fos	
INTRACELLULAR TURNOVER									
0.002	0.95	0.10	0.43	0.27	1.37	0.11	X92664	Ubiquitin-conjugating enzyme Liver, skeletal muscle (ubiquitous) UbcM2 (E2); nonlysosomal protein degradation system; histone ubiquitination alters chromatin structure	
0	1.11	0.11	0.00	0.00	1.02	0.10	X71978	Ft1, a novel gene related to ubiquitin-conjugating enzymes; deletion leads to partial syndactyly of the limbs and thymic hyperplasia, suggesting impaired programmed cell death	
CHROMATIN STRUCTURE									
0.028	1.33	0.95	0.00	0.00	1.79	0.49	L04141	Histone H1 subtype (H1e); Liver (ubiquitous) chromatin structure	
0.000	1.74	0.30	0.00	0.00	1.08	0.24	J03482	Histone H1; chromatin structure	Ubiquitous
0.000	1.69	0.18	0.02	0.03	1.09	0.27	ET62262	Histone H1b; chromatin structure	Ubiquitous
0.030	1.41	0.26	0.34	0.53	1.10	0.24	ET62908	Histone H2B; chromatin structure	Liver (ubiquitous)
0.038	1.20	0.27	0.00	0.00	0.79	0.70	U62675	Histone H3.2-616, and histone H2b-616; chromatin structure	Liver (ubiquitous)
0.006	1.08	0.12	0.15	0.18	1.12	0.40	U62672	Histone H3.1-D (H3-D) and histone H4-D (H4-D) genes; chromatin structure	Ubiquitous

0.024 1.22 0.82 0.00 0.00 1.36 0.11

X16495

Histone H2A;

chromatin Ubiquitous

<0.001 1.07 0.13 0.00 0.00 1.19 0.13

U62669

Histone H3.2-F (H3-F), histone Ubiquitous
H2a.1-F (H2a-F), histone H2b-F
(H2b-F); chromatin structure

0.034 1.11 0.15 0.30 0.52 1.16 0.21

X56044

Htf9-c; structural similarity with Liver (ubiquitous)
yeast and bacterial nucleic acid-
modifying enzymes; activated at
the G1/S transition, maximum
and S phase; down in growth
arrested cells

0.009 1.06 0.11 0.28 0.48 1.44 0.21

X56690

Homologous to Drosophila HP1 Ubiquitous during development
gene; modifs chromatin,
rendering heritable changes in
gene expression; activates or
silences genes
SURF-6; involved in a nucleolar Nucleolus (ubiquitous)
ribosome
housekeeping

0.025 1.51 0.35 0.27 0.47 0.99 0.36

X92842

silences genes
SURF-6; involved in a nucleolar Nucleolus (ubiquitous)
ribosome
housekeeping

CELL CYCLE / CELL
DIVISION

0.022 1.11 0.17 0.00 0.00 0.82 0.60

X66285

HC1 gene; mouse gene homologous to the E5 ORF from bovine
papillomavirus type 1; transforms immortalized rodent cells.

0.000 1.09 0.27 0.00 0.00 1.54 0.14

ET62229

Wnt10b;
regulation of cell growth and embryos and in adult
differentiation in certain adult
mammalian tissues

0.003 1.66 0.58 0.00 0.00 1.11 0.22

ET61747

Citron; Rho (controls actin Ubiquitous
structures) target protein; role in
cytokinesis

0.001 1.93 0.38 0.00 0.01 1.12 0.45

Y00848

Int-2 (FGF-3); expressed in Early embryogenesis; discrete
embryonic development regions during development; not
reported in adult

0.002 1.46 0.17 0.47 0.20 1.08 0.17

X61940

Mitogen-activated protein kinase Liver parenchymal cells, vascular
phosphatase (MKP-smooth muscle, others
1/3CH134/ERP1); serum growth
factor-induced immediate early

P	CR	std	CON	std	SW	std	GenBank	Description	MAP	Location
								gene; dephosphorylates kinase		
<0.001	1.08	0.07	0.00	0.00	1.05	0.20	Z7200Q	BTG3; negative control of cell Fibroblast, brain cycle		
<0.001	1.13	0.11	0.03	0.05	1.04	0.16	X07540	C-abl; a nonreceptor tyrosine kinase; appears to play a role in cell cycle progression, cell proliferation and differentiation		Liver, B cells
0.006	1.02	0.02	0.00	0.00	0.92	0.45	U10440	G1 cyclin-Cdk protein kinase Ubiquitous inhibitor p27, cell cycle; cyclin-dependent kinase inhibitor p27 (Kip1)		
0	1.08	0.17	0.00	0.00	1.29	0.21	ET61628	Phosphoinositide 3-kinase Liver (regulatory subunit p85alpha); plays critical roles in cell growth, differentiation, survival, and vesicular transport		
0.002	1.48	0.47	0.00	0.00	1.26	0.23	ET61257	Map Kinase Kinase Kinase (MEKK Ubiquitous 1) ; MEK kinases (MEKKs) are serine-threonine kinases that regulate sequential protein phosphorylation involving mitogen-activated protein kinases (MAPKs), including members of the Jun kinase (JNK) family.		
0.002	1.10	0.41	0.00	0.00	1.25	0.22	U85608 (was U11548)	Mitogen-activated protein kinase Liver (15 times higher in fetal than (MAPK); signal transduction; adult); ubiquitous important in cell proliferation, differentiation, and apoptosis; induced by epidermal growth factor; activation of MAPK induces c-Fos and c-Jun; CR reduces the age related decline in MAPK activation		
0.002	1.09	0.31	0.00	0.00	1.39	0.39	M31419	Interferon-activatable gene (204); Nucleoimmediates antimicrobial,		

GenBank Description Location

P CR std CON std SW std

immunomodulatory and cell growth-regulatory activities of interferons; increased up to 75-fold by alpha-interferon treatment

DNA REPLICATION/REPAIR

0.029	1.36	0.37	0.48	0.34	1.27	0.24	D13544	Primase small (p49) subunit; cell proliferation; DNA replication	Liver (ubiquitous)
0.025	1.24	0.37	0.45	0.16	1.14	0.25	X74351	XPAC (Xeroderma Pigmentosum Ubiquitous group A Correcting protein); nucleotide excision DNA repair	
0.001	1.03	0.29	0.00	0.00	1.27	0.30	ET62746	Brca2 gene; familial breast cancer susceptibility gene; important in DNA double-strand break repair (DSBR) and DNA damage-induced cell-cycle checkpoint activation	Ubiquitous
<0.001	1.17	0.13	0.13	0.14	1.07	0.19	X58472	KIN17, DNA-binding, nuclear protein, upregulated in response to UV and ionizing radiation; accumulated in the nucleus of proliferating fibroblasts; overexpression inhibits progression into S phase	
0.009	1.02	0.03	0.17	0.14	0.85	0.37	ET63479	MLH1; DNA mismatch repair gene; function in mutation avoidance; cell cycle checkpoint control; cytotoxicity of various DNA-damaging agents; transcription-coupled nucleotide excision repair.	Ubiquitous

APOPTOSIS

0.005	1.07	0.19	0.33	0.30	1.36	0.23	Z37110	Cyclin G; augments apoptosis; target gene of P53	Liver
0.000	1.00	0.09	0.42	0.05	1.12	0.04	ET63241	Apoptain precursor caspase-3; YAMA protein; cysteine protease; mediator of	(LICE; Liver, neurons, lung, kidney, spleen, lymphocytes)

P	CR	std	CON	std	SW	std	GenBank	Description	Location
<0.001	1.14	0.13	0.05	0.09	1.06	0.11	X58876	apoptosis; processes precursor IL-1; PARP-cleaning Mdm2 is a P53 specific ubiquitin ligase; promotes the ubiquitination and proteasome- dependent degradation of p53; immediately after cellular stress, MDM2 ability to bind to p53 is blocked, preventing MDM2- mediated degradation, P53 levels rise causing cell cycle arrest or apoptosis	Liver
<0.001	1.12	0.15	0.00	0.00	1.08	0.24	L22472	Bax alpha; Bcl-2-family protein with pro-apoptotic activity; can form channels in lipid membranes	Liver
0.001	1.21	0.28	0.00	0.00	1.16	0.22	L31532	Bcl-2-beta; suppresses programmed cell death	Liver
0.050	1.25	0.15	0.47	0.50	1.01	0.07	U48804	Zn-finger protein Pw1/Peg3; Ubiquitous activates NFkappaB; regulator of TNF response; induced during p53/c-myc-mediated apoptosis; Pw1/Peg3 with Siah1a induces apoptosis independently of p53; inhibiting Pw1/Peg3 activity blocks p53-induced apoptosis.	Ubiquitous
0	0.91	0.19	0.00	0.00	1.08	0.06	ET61211	RNA-dependent EIF-2 alpha Ubiquitous kinase; double-stranded (ds) RNA-dependent protein kinase (PKR); key mediator of antiviral effects of interferon (IFN); active player in apoptosis.	Ubiquitous
0	1.11	0.11	0.00	0.00	1.02	0.10	X71978	Ft1, a novel gene related to ubiquitin-conjugating enzymes; deletion leads to partial syndactyly of the limbs and thymic hyperplasia, suggesting impaired programmed cell death	Ubiquitous
SERUM PROTEINS / SECRETED PROTEINS									
0.000	1.28	0.19	0.11	0.19	0.95	0.09	V00743	Alpha-fetoprotein (AFP); component of mammalian fetal	main Liver (fetal & adult)

P	CR	std	CON	std	SW	std	GenBank	Description	Location
<0.001	1.10	0.09	0.07	0.12	1.07	0.16	M16395	serum; synthesized by visceral endoderm of the yolk sac and by fetal liver; blood level decreases after birth; synthesis reactivated in liver tumors Alpha-fetoprotein (AFP); main Liver (fetal & adult) component of mammalian fetal serum; synthesized by visceral endoderm of the yolk sac and by fetal liver; blood level decreases after birth; synthesis reactivated in liver tumors	
0.018	1.14	0.13	0.38	0.42	1.30	0.26	X03479	Serum amyloid A (Saa) 3; serum Liver protein; major acute phase protein	
0.049	1.15	0.64	0.57	0.18	1.71	0.35	ET63455	Serum amyloid A-4 protein Epithelial cells in a variety of tissues (Saa4); a minor, normal high-density lipoprotein (HDL, apolipoprotein); acute-phase apolipoprotein; induced by trauma and inflammation; normally rapidly catabolized; degraded by secreted or cell-associated neutral proteases generated by macrophages	
0.008	1.57	0.50	0.14	0.25	1.00	0.25	V00829	Kallikrein; serine protease; Liver generates proinflammatory kinins; processes peptides	
0.002	1.27	0.40	0.00	0.00	1.35	0.31	X61597	Kallikrein-binding protein; tissue Liver, lung, thymus kallikrein regulation; serine proteinase inhibitor superfamily	

EXTRACELLULAR MATRIX / CELL ADHESION

0.002	1.60	0.32	0.03	0.05	1.17	0.41	Z50147	Cell adhesion regulator; Liver extracellular matrix protein	
0.000	1.34	0.27	0.05	0.08	0.95	0.11	X06115	E-cadherin; cell-cell adhesion; cell Liver (epithelial cells) surface glycoprotein; transmembrane protein	

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.001	1.04	0.07	0.38	0.16	1.12	0.12	U19521	Vesicle transport protein (munc- Ubiquitous vesicles)	
0.001	1.12	0.15	0.43	0.09	1.06	0.13	X14972	Alpha-adaptin; adaptor complex Liver and brain components; link clathrin to coated vesicle receptors	
<0.001	1.05	0.07	0.00	0.01	1.04	0.17	Z22821	Rab23; Ras-related small GTPase; Liver protein trafficking; central regeneration leads to regulatory elements of the other cells intracellular transport machinery; regulate vesicle docking and fusion, organelle dynamics	
0.003	1.23	0.28	0.00	0.00	1.28	0.45	D29797	Syntaxin 3A, IER vesicular Liver transport, membrane fusion	
<0.001	1.08	0.09	0.01	0.02	1.13	0.11	X66449	Calcyclin, also called S100A6; Epithelial cells and fibroblasts of calcium binding protein; mucus liver; breast, heart, intestine, kidney, ovary, placenta, stomach, thymus, and uterus; high levels of expression in epithelial lining the gastrointestinal, respiratory and urinary tracts	
0.001	1.21	0.18	0.00	0.00	1.12	0.29	U96700	Serine proteinase inhibitor 6 Lymphocytes; endothelial (SPI6); not secreted, remains in epithelial cells; platelets the endoplasmic reticulum; intracellular function unclear	
0.013	1.10	0.15	0.00	0.00	1.05	0.58	L39373	N-acetylglucosaminyltransferase Liver III (Mgat3); transfers the bisecting GlcNAc to the core of complex, N-linked carbohydrates	
0.001	0.97	0.15	0.48	0.11	1.08	0.07	U58513	Rho kinase (p160, ROCK-2); Rho Ubiquitously expressed except in the is a small GTPase; brain and muscle serine/threonine coiled coil-forming protein kinase; downstream targets include LIM-kinase 1, which phosphorylates cofilin, an actin-depolymerizing factor; regulates actin	

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.009	2.03	0.56	0.24	0.41	1.11	0.39	U96724	activity enhances secretion; phosphorylation of myosin light chain and moesin may prevent pathologic platelet activation during atherogenesis. Phosphatidylinositol transfer protein alpha (Pitpn); cytosolic protein binds phosphatidylinositol and transfers it between membranes; mutant in this gene (the mouse vibrator mutation) causes an early-onset progressive action tremor, degeneration of brain stem and spinal cord neurons, and juvenile death.	Ubiquitous
0.001	1.27	0.13	0.07	0.12	0.94	0.31	X78304	Signal recognition particle (SRP9); cytoplasmic ribonucleoprotein; synthesis and translocation of secreted proteins	Ubiquitous
0.001	1.01	0.08	0.15	0.25	1.22	0.18	ET62525	Polypeptide N- Wide expression pattern; detected in acetylgalactosaminyltransferase- embryonic tissues, as well as adult T4 (polypeptide GalNAc sublingual gland, stomach, colon, transferase-T4; ppGalTase-T4); small intestine, lung, cervix, and fourth member of the mammalian uterus; lower levels detected in UDP-GalNAc; Golgi-like kidney, liver, heart, brain, spleen, localization; 4 GalNAc- and ovary transferase controls the initiation of mucin-type O-linked protein glycosylation, in which N-acetylgalactosamine is transferred to serine and threonine amino acid residues	
0.017	1.07	0.06	0.25	0.44	0.97	0.11	X14926	Calreticulin; endoplasmic reticulum chaperone; also functions in calcium storage and signaling, and cell attachment; nuclear matrix component	
0.017	1.61	0.70	0.00	0.00	1.45	0.59	X75636	Iduronato-2-sulfatase (IDS); Ubiquitous	

P	CR	std	CON	std	SW	std	GenBank	Description	Location
								degrades heparin sulfate and dermatan sulfate in lysosomes; deficiency causes fatal lysosomal storage disorder: mucopolysaccharidosis type II (the glycosaminoglycans heparin sulfate and dermatan sulfate accumulate); part of proteoglycans which bind, help package and store secretory molecules; function in cell adhesion and basal lamina formation	

TRANSLATION

0.011	1.04	0.05	0.29	0.28	1.12	0.31	U28419	Translation initiation factor eif-4C Ubiquitous homologue	
0.000	1.48	0.24	0.00	0.00	1.05	0.08	X57960	Ribosomal protein L7; Ubiquitous incorporated into 60 S subunit	
0.013	1.17	0.22	0.37	0.29	1.04	0.18	M29015	Ribosomal protein L7 (rpL7); Ubiquitous incorporated into 60 S subunit	
<0.001	1.06	0.05	0.00	0.00	1.18	0.25	K02060	Ribosomal protein L32 Ubiquitous	
0.001	1.27	0.13	0.07	0.12	0.94	0.31	X78304	Signal recognition particle Ubiquitous (SRP9); cytoplasmic ribonucleoprotein; synthesis and translocation of secreted proteins	

TRANSCRIPTION

0.026	1.20	0.18	0.34	0.35	1.36	0.48	X74040	Mesenchyme fork head-1 (MFH- H + J509 hepatocytes 1) transcription factor	
0.016	1.32	0.28	0.31	0.26	1.08	0.37	ET61028	ARE Binding Protein (AREC3) Many cell-types during development; muscle in adult	
0.005	1.16	0.04	0.00	0.00	0.77	0.46	ET62446	Sox12; transcription factor; Sox Developing embryos family plays important role in development	
0.018	1.19	0.27	0.39	0.32	1.14	0.18	X55781	Pax2 transcription factor; paired Developing embryo excretory and box family (homologous to CNS Drosophila segmentation genes)	
0.032	1.16	0.18	0.50	0.35	1.26	0.09	ET62078	Putative transcription factor Many locations in embryo during	

P	CR	std	CON	std	SW	std	GenBank	Description	Location
								(tbx4); T-box DNA binding development domain; putative roll in inductive interactions during embryogenesis	
0.003	1.06	0.13	0.48	0.25	1.31	0.11	X75018	Id4; CD44; dominant negative Embryogenesis, up-regulated regulators of bHLH transcription between day 9.5 and 13.5 of factors; differentiation in cellular gestation; adult highest expression systems including myogenesis, testis, brain and kidney; also in liver; neurogenesis and adipocytes, muscle cells haematopoiesis; adipocyte and others differentiation	
0.009	1.56	0.64	0.00	0.00	1.47	0.44	L28167	Zinc finger protein, the Kruppel-Liver, lens, heart, kidney, spleen, associated box (KRAB); similar brain of newborn mice to profilaggrin (expressed in differentiating epidermal cells)	
0.003	1.17	0.37	0.10	0.16	1.21	0.18	U13878	Neural-restrictive silencer factor Many nonneuronal cells and tissues (NRSF/REST); transcription factor; represses expression of neuronal genes including mACHR, SCG-10 and type II sodium channel genes; recruits mSin3 and histone deacetylase	
<0.001	1.09	0.12	0.11	0.13	1.09	0.09	X89264	Zinc-finger protein Zfp-37; Liver transcription factor (putative); peroxisome proliferator responsive; contains Kruppel-associated box	
0.018	1.18	0.62	0.08	0.07	1.06	0.08	U15443	C-ros (c-ros); embryonic Neoplastic and fetal tissues development; tyrosine kinase catalytic domains; expressed in neoplastic and fetal tissues	
0.003	1.24	0.40	0.00	0.00	1.25	0.32	X59251	Hox-7; transcription factor; early Embryogenesis stage of eye developmental regulation in embryo	
0.001	1.12	0.27	0.10	0.18	1.17	0.12	M28449	Hox-1.7; homeobox; transcription Embryogenesis factor	
0.01	1.53	0.65	0.00	0.00	1.50	0.46	X56182	Myf-5; myogen factor 5; Embryonic liver and heart	

P	CR	std	CON	std	SW	std	GenBank	Description	Location
								transcription factor; helix-loop-helix family	
0.047	1.45	0.81	0.00	0.00	1.42	0.72	X13538	Hox-1.4; transcription factor	Embryonic spinal cord and adult testis
0.001	1.23	0.23	0.03	0.05	1.11	0.26	X60034	Hox-4.9; homeobox; transcription factor	Neurogenesis
0.002	1.27	0.23	0.00	0.00	1.14	0.38	X80339	Six1; homeobox; development of limb tendons	Skeletal and smooth muscle
0.024	1.56	0.52	0.00	0.00	1.49	0.83	D00925	Transcription factor S-II-related protein; transcription elongation factor	Liver
0.003	1.17	0.15	0.13	0.22	0.88	0.27	X67719	CREBcAMP-responsive-element binding protein	Ubiquitous
0.009	1.50	0.67	0.00	0.00	1.34	0.29	X60136	Sp1; transcription factor; zinc finger protein	Ubiquitous
<0.001	1.16	0.03	0.09	0.15	1.02	0.07	X80508	Yes-associated protein (YAP65); transcription activator	Ubiquitous
<0.001	1.07	0.06	0.00	0.00	0.95	0.13	X76858	Phi AP3, nuclear factor; DNA binding transcription factor; inactivates adjacent enhancer function; GLI-Kruppel related; cell-cycle regulated	Ubiquitous
0.002	1.99	0.65	0.00	0.00	1.08	0.19	Y12783	Ring1B; interacts directly with the repressor domain of M33; M33 is a transcription factor implicated in mesoderm patterning in the mouse; in Drosophila, homologue genes maintain repression of developmental genes including homeotic genes	Expression distribution not reported
0.003	1.08	0.17	0.17	0.29	1.41	0.32	X55315	CAAT-box DNA binding protein subunit A (NF-YA)	Ubiquitous
0	1.36	0.25	0.00	0.00	1.02	0.04	X15842	C-rel; encodes a member of the Rel/nuclear factor (NF)-kappaB family of transcriptional factors	Ubiquitous

RNA SPLICING / PROCESSING

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.011	1.06	0.08	0.38	0.33	1.04	0.10	ET63161	Alternative splicing factor (ASF); recruits basal splicing factors during spliceosome assembly	Ubiquitous (?)
0.001	1.04	0.12	0.15	0.26	1.07	0.07	Y08260	CPEB protein; RNA binding protein that interacts with the maturation-type cytoplasmic polyadenylation element to promote polyadenylation and translational activation	Ubiquitous
0.004	1.14	0.19	0.00	0.00	1.02	0.44	X91656	Srp20 gene; splicing factor belonging to the highly conserved family of SR proteins; multiple roles in the regulation of constitutive and alternative splicing	Ubiquitous

MEMBRANE PROTEIN

0.003	1.08	0.17	0.00	0.00	1.47	0.51	M17376	Alpha-1-acid glycoprotein I (AGP-1); membrane protein	Liver
0.001	1.48	0.19	0.00	0.00	0.97	0.37	M75875	MHC class I T3-d gene; haplotype; beta-2-microglobulin associated protein; cell surface glycoprotein; class I antigen	Unknown
0.036	1.09	0.10	0.44	0.38	1.09	0.23	J03298	Major histocompatibility complex DO beta gene	Ubiquitous
0.001	1.76	0.14	0.01	0.01	1.02	0.47	D90146	MHC gene Q8/9d Qa-2,3 class I antigen	Ubiquitous
0.001	1.12	0.29	0.00	0.00	1.16	0.18	U06662	59-kd oncofetal antigen; antigens present on the surface of all major classes of rodent tumors	not reported in adult
0.008	1.07	0.73	0.00	0.00	1.73	0.16	X61576	Connexin 43; gap junction proteins; contain ion channels that generate signals throughout the tissue	Liver, heart, bone, skin, etc.; Mol
0.024	1.41	0.69	0.00	0.00	1.45	0.61	M91243	Connexin family of gap junction (cell-to-cell channels) proteins (Cx50); likely IS lens fiber protein	Ubiquitous

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.023	1.38	0.74	0.00	0.00	1.30	0.40	X54424	Gamma adaptin; major Liver (ER) component of adaptor; the protein complex links clathrin to transmembrane proteins in coated pits and vesicles	
0.005	1.43	0.52	0.00	0.00	1.37	0.38	U49185	Occludin; occludin is a Liver transmembrane protein located at tight junctions and is known to interact with other tight junction proteins	
0.027	1.28	0.32	0.60	0.13	1.43	0.37	M81591	CD10 neutral endopeptidase Ubiquitous 24.11 (CD10/NEP); cell surface metalloproteinase; activation marker for mononuclear cells; peptide mediated signal transduction; inactivates numerous endogenous peptides in the brain, kidney, and lung in vivo	
0.009	1.06	0.75	0.00	0.00	1.93	0.43	Z22216	Apolipoprotein C2 (APOC2); Fetal liver, adult liver, intestine and required for lipolysis of peritoneal macrophages triglycerides by lipoprotein lipase	
0.026	1.09	0.03	0.50	0.19	0.93	0.27	V00834	MHC class II H2-IE-alpha B cells, IgE	
0.003	1.16	0.07	0.46	0.13	0.90	0.21	X68061	Beta-2-microglobulin; membrane Liver (hepatocytes) protein; 45,000 MW HLA antigen	
0.002	0.99	0.29	0.00	0.00	1.38	0.36	M23383	Glucose transporter 2 Liver	
0.038	1.24	0.60	0.22	0.28	1.08	0.12	ET63259	Cea14 gene (carcinoembryonic antigen family members); liver	Many cea genes expressed in fetal
0	1.08	0.15	0.18	0.17	1.32	0.16	ET63260	unknown function; member of the immunoglobulin superfamily	Many cea genes expressed in fetal
0.001	1.04	0.04	0.22	0.12	1.16	0.28	ET63261	Cea15 gen (carcinoembryonic antigen family members); liver	Many cea genes expressed in fetal
								unknown function; member of the immunoglobulin superfamily	
								Cea16 gene (carcinoembryonic antigen family members); liver	Many cea genes expressed in fetal

P	CR	std	CON	std	SW	std	GenBank	Description	Location
the immunoglobulin superfamily									

METABOLISM / ENERGY GENERATION

0.003	0.97	0.05	0.18	0.26	1.34	0.33	U00932	Glutamine; fructose-6-phosphate amidotransferase (GFAT); rate-limiting enzyme in hexosamine synthesis	Liver
0.016	1.10	0.16	0.33	0.41	1.24	0.21	D21826	CMP-N-acetylneuraminic hydroxylase; ganglioside expression	acid Liver
0.001	1.08	0.31	0.00	0.00	1.58	0.32	X98792	Prostaglandin synthase	Liver
0.002	1.23	0.28	0.01	0.02	1.42	0.41	M29395	cyclooxygenase Down in CR	Liver
<0.001	1.01	0.03	0.01	0.01	1.11	0.10	X72959	Orotidine-5'-monophosphate decarboxylase; conversion of orotidine 5'-monophosphate to UMP; UMP biosynthetic pathway.	Liver
0.001	1.10	0.13	0.06	0.10	1.20	0.30	J04947	Nat3 gene for N-acetyltransferase ACE; angiotensin-converting enzyme	Liver
<0.001	1.16	0.02	0.04	0.08	1.02	0.13	L09105	Glucose phosphate isomerase	Ubiquitous
0.039	1.39	0.70	0.00	0.00	1.56	0.80	X14489	Thymidylate synthase (TS)	Ubiquitous (all proliferating cells)
0.005	1.37	0.42	0.00	0.00	1.54	0.51	U34071	Alpha-galactosidase A; lysosomal enzyme	Ubiquitous (most cases)
0.004	1.08	0.20	0.51	0.17	1.11	0.03	J00355	Alpha-amylase-1 (Amy-1A); glycogen digestion and mobilization	Liver and salivary glands
0	1.10	0.09	0.29	0.05	1.20	0.19	X07888	3-hydroxy-3-methylglutaryl coenzyme A reductase; key regulatory enzyme for cholesterol biosynthesis.	Liver

ION CHANNELS / PUMP

0.000	1.42	0.20	0.00	0.00	0.95	0.14	ET61677	Epithelial sodium channel subunit	alpha Liver
0.044	1.33	0.44	0.35	0.34	1.07	0.33	U03723	AKR voltage-gated potassium channel (KCNA4)	Ubiquitous
0.039	1.24	0.23	0.45	0.34	1.09	0.31	M30441	Potassium channel gene (MK3)	Ubiquitous
0	1.27	0.05	0.13	0.13	1.07	0.13	ET61590	Putative capacitative calcium channel	Brain, kidney, heart and lung, no trp

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.002	1.19	0.35	0.06	0.10	1.43	0.34	ET61440	entry channel (Trp6); involved in message detected in liver calcium entry secondary to activation of receptors coupled by the Gq class of G protein. Trp-related protein 3; cation Endothelium channel; essential for agonist-activated capacitative Ca2+ entry; putative subunits of CCE channels	
NUCLEAR RECEPTORS									
0.016	1.38	0.67	0.07	0.13	1.28	0.26	X07751	Thyroid hormone receptors	Liver
0.003	1.24	0.31	0.13	0.16	1.23	0.26	X04435	Glucocorticoid receptor	Liver
<0.001	1.20	0.23	0.03	0.05	1.11	0.15	X74134	COUP-TF1; steroid hormone receptor; transcription factor	Liver
0.01	1.13	0.12	0.00	0.00	1.21	0.61	X76653	Apolipoprotein regulatory protein1 (ARP-1); member of the COUP-family of steroid hormone orphan receptors	Liver, lung, kidney
0.049	0.90	0.55	0.35	0.04	1.40	0.43	X59411	Androgen receptor	Sex glands, liver, heart, kidney, bone pituitary,
CYTOKINE/GROWTH FACTOR									
0.003	1.10	0.23	0.11	0.18	1.61	0.45	X57413	Transforming growth factor-beta2 (TGFbeta2); proliferation	factor- Liver stellate cells cell
0.012	1.11	0.23	0.35	0.32	1.05	0.06	ET62118	Keratinocyte factor/fibroblast growth factor-7 precursor (mKGF)	growth Liver epithelial cells
0.001	1.38	0.08	0.00	0.00	0.94	0.40	Z29532	Follistatin; binds and inactivates activin; up-regulated by mediators of inflammation; control of the inflammatory cascade	Liver
0.000	1.41	0.13	0.11	0.17	0.94	0.25	M28587	Alpha leukocyte interferon (MuIFN-alpha A); inhibition of proliferation	Ubiquitous
0.015	1.31	0.23	0.44	0.35	1.04	0.13	V00755	Interferon beta (type 1); growth factor; T helper cell	Ubiquitous

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.002	1.10	0.10	0.48	0.17	1.15	0.16	M30644	differentiation factor; antiviral; modulates immune responses to foreign and self-antigens Basic fibroblast growth factor Endothelial cells (vascular); pituitary; (Fgfb; FGF-2); potent trophic peritoneal mesothelial cells; effects on neurons, glia and astrocytes; leukocytes endothelial cells; mitogen, differentiation and survival factors, angiogenic factor; levels are markedly elevated after liver injury; stimulates hepatocyte proliferation and migration at the wound front;	
<0.001	1.12	0.04	0.09	0.15	1.12	0.21	X53257	NT-3 gene for neurotrophin-3; Liver parenchymal cells, olfactory secreted protein; binds high bulb, cerebellum, septum, affinity receptor trk C; postnatal hippocampus; thymus, heart, development? diaphragm, pancreas, spleen, kidney, adrenal	
0.001	1.07	0.07	0.10	0.17	1.13	0.23	J00424	Interferon-beta	Liver
0.001	1.10	0.11	0.02	0.02	1.18	0.38	U96386	Activin beta E subunit, member of TGF-beta superfamily	Liver
0.005	1.24	0.41	0.00	0.00	1.28	0.39	X69620	Inhibin beta-B subunit; activins are dimeric proteins, members of the transforming growth factor beta (TGF-beta) gene superfamily, consisting of beta-subunits of inhibin (betaA and betaB)	Liver
0.003	2.25	0.40	0.18	0.32	1.19	0.55	X99572	C-fos-induced growth factor (FIGF); secreted dimeric protein member of the platelet-derived embryonic growth endothelial growth factor (PDGF/VEGF) family; mitogenic and morphogenic activity on fibroblasts.	Endothelial cells, expressed in many tissues (including liver) during development
0.003	1.11	0.10	0.26	0.26	1.17	0.22	U07982	Preproendothelin-1; induces fibroblast growth	Vascular wall (endothelial cells,

P	CR	std	CON	std	SW	std	GenBank	Description	Location
								smooth muscle	alpha-actin arterial smooth muscle cells, select expression; induced in stellate epithelial cells); kidney, lung, and endothelial cells of liver after trachea; liver (nonparenchymal cells, injury predominantly in sinusoidal endothelial cells)

SIGNAL TRANSDUCTION

0.004	1.30	1.09	0.29	0.19	1.09	0.19	X82320	Stathmin; phosphoprotein participating in relay and integration of intracellular signaling pathways involved in control of cell proliferation, differentiation, and other activities	cytosolic Ubiquitous
0.041	1.19	0.25	0.41	0.28	1.13	0.40	X13664	N-ras; key component of growth signaling pathways; transmits membrane receptor kinase signals; GTP-binding switch protein	Liver, wide tissue distribution
0.002	1.46	0.17	0.47	0.20	1.08	0.17	X61940	Mitogen-activated protein kinase phosphatase 1/3CH134/ERP1); serum growth factor-induced immediate early gene; dephosphorylates MAP kinase	Liver parenchymal cells, vascular (MKP-smooth muscle, others
0.004	1.17	0.48	0.00	0.00	1.09	0.15	S45828	Serine/threonine/tyrosine kinase (Nek1); related to the NIMA (a protein kinase which controls initiation of mitosis in Aspergillus nidulans)	All organs examined
0.001	1.09	0.27	0.10	0.15	1.23	0.22	U65313	Ras-GTPase-activating domain binding protein (G3BP); essential for Ras signaling	SH3- Ubiquitous
0.013	1.02	0.03	0.00	0.00	1.02	0.57	M63658	G protein beta-subunit	Brain, liver, blood cell
0.003	1.09	0.11	0.03	0.05	1.25	0.45	U38501	G protein alpha i1 subunit	Liver; cerebral cortex; pancreatic acinar cells; white adipose tissue; others
0.010	1.32	0.28	0.24	0.41	1.06	0.11	AA162130	SUMO-1 activating enzyme	Ubiquitous

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.003	1.11	0.50	0.00	0.00	2.16	0.55	ET63005	Phospholipase C gamma 1; Ubiquitous; hepatocytes; hepatic substrate of many growth factor stellate cells; vascular smooth receptor and nonreceptor tyrosine muscle; vascular endothelial cells kinases; produces second messenger molecules that are elements of signal transduction pathways related to cell proliferation.	
0.001	0.97	0.15	0.48	0.11	1.08	0.07	U58513	Rho kinase (p160, ROCK-2); Rho Ubiquitously expressed except in the is a small GTPase; brain and muscle serine/threonine coiled coil-forming protein kinase; downstream targets include LIM-kinase 1, which phosphorylates cofilin, an actin-depolymerizing factor; regulates actin cytoskeletal reorganization; Rho activity enhances secretion; phosphorylation of myosin light chain and moesin may prevent pathologic platelet activation during atherogenesis.	
0.002	1.48	0.47	0.00	0.00	1.26	0.23	ET61257	Map kinase kinase kinase (MEKK 1); serine-threonine kinase; regulates sequential protein phosphorylation pathways involving mitogen-activated protein kinases (MAPKs), including some Jun kinases	
0.002	1.10	0.41	0.00	0.00	1.25	0.22	U85608 (was	Mitogen-activated protein kinase Liver (15 times higher in fetal than (MAPK); signal transduction; adult); ubiquitous	

P	CR	std	CON	std	SW	std	GenBank U11548)	Description;	Location
0.004	1.09	0.08	0.12	0.20	0.89	0.32	ET62570	Mad homologue Smad5; Liver downstream component in the TGF-beta family signaling cascade, transduces signals from the cell surface to the nucleus; participates in regulation of gene expression; essential in left/right isomerism and liver development; essential for angiogenesis	
0.001	1.24	0.31	0.00	0.00	1.18	0.27	D50095	Histamine H1 receptor; GTP-Liver, brain, spleen (ubiquitous) binding protein-coupled receptor; coupled to phosphoinositide turnover-calcium mobilization signaling pathway; regulates insulin-like growth factor I expression and cell proliferation; modulates IL-6 action; regulates physiological functions in neurons; regulates transport of thyroxine into hepatocytes	
0	1.09	0.16	0.00	0.00	1.15	0.13	U60330	Ki antigen (PA28 gamma); cell Liver, neurons, proliferation; the interferon-distribution gamma (IFN-gamma)-inducible PA28 activator complex enhances the generation of class I binding peptides by altering the cleavage pattern of the proteasome	broad tissue
0.002	1.09	0.31	0.00	0.00	1.39	0.39	M31419	Interferon-activatable gene (204); Nucleoimediates antimicrobial,	

P	CR	std	CON	std	SW	std	GenBank	Description	Location
immunomodulatory and cell growth-regulatory activities of interferons; increased up to 75-fold by alpha-interferon treatment									

MEMBRANE RECEPTORS

0.029	1.11	0.15	0.33	0.38	1.39	0.49	U40189	Pancreatic polypeptide/neuropeptide Y/peptide YY receptor (NPYR-D); G protein-coupled	Liver
0	1.00	0.15	0.02	0.03	1.15	0.10	U58367	Neuropeptide Y receptor Neurons, Y5/Y6/Y2b (referred to as both cells Y5 and Y2b, has now been designated as Y6 in literature); (NPY-Y6); (neuropeptide Y is an important regulator of energy balance in mammals through its orexigenic, antithermogenic, and insulin secretagogue actions; expressed abundantly in the central nervous system); NPY receptors mediate a variety of physiological responses including feeding and vasoconstriction	Neurons, vascular smooth muscle
0.027	1.12	0.15	0.31	0.34	0.95	0.32	X76295	Melanocortin 5 receptor; G- protein-coupled receptor; stimulates adenylyl cyclase	Widely expressed
0.020	1.89	0.60	0.00	0.00	1.29	0.82	ET61559	Bradykinin B1 subtype receptor; G protein-coupled membrane bound; T-kininogen modulation during acute phase protein synthesis	Liver (ubiquitous)
0.013	2.14	0.64	0.17	0.16	1.38	0.69	X99581	Chemokine receptor; receptor stromal cell-derived factor/pre-B growth stimulating factor; seven transmembrane domain receptor	Liver and bone marrow
0.001	1.46	0.18	0.38	0.22	0.98	0.10	ET61693	Leptin receptor	(OB-R); Lung, liver, muscle, brain;

P	CR	std	CON	std	SW	std	GenBank	Description	Location
								transmembrane receptor	developing bone, mesenchyme, notochord and liver (Am J Clin Nutr 1999 Jan;69(1):18-21)
0.000	1.52	0.10	0.00	0.00	0.97	0.19	U28404	Macrophage protein-1 alpha receptor; mediates growth inhibitory effects of the chemokine CD44; receptor for hyaluronan; cell surface glycoprotein; hyaluronan clearance from the blood; involved in lymphocyte homing and activation;	inflammatory MIP-1alpha RL2 in liver and spleen
0.017	1.10	0.20	0.48	0.29	1.12	0.12	U57612	BEK fibroblast growth factor receptor (BEK FGF receptor, FGF- others 2), membrane-spanning tyrosine kinase; activated by three members of the FGF family; activation causes the foregut endoderm to develop into the liver	Liver, central nervous system, lung, liver epidermis, and pancreas
<0.001	1.24	0.25	0.00	0.00	1.28	0.24	M86441	Member of the mannose receptor type C (calcium dependent) lectin family; critical for processes ranging from cell adhesion to antigen presentation; gene family includes macrophage mannose, the phospholipase A2, and the DEC 205 receptors;	Widespread tissue distribution; fetal sites; endothelialized chondrocytes in cartilaginous regions of the embryo
<0.001	1.04	0.05	0.00	0.00	1.13	0.20	U56734	Macrophage colony-stimulating factor-1 (CSF-1) receptor	C liver;
0.002	1.17	0.15	0.06	0.11	1.27	0.38	X06368	Ryanodine receptor type 2; Ca2+ channels in the ER; intracellular release channels controlling cytosolic calcium levels.	cardiac muscle; neurons; most membrane excitable cells; liver
0.001	1.13	0.15	0.02	0.03	1.21	0.34	X83933	Transferrin receptor;	cell surface
0.003	1.19	0.38	0.00	0.00	1.23	0.31	x57349		Liver

P	CR	std	CON	std	SW	std	GenBank	Description	Location
								glycoprotein; cell growth; binds the major serum iron-transport protein, transferrin, and mediates cellular iron uptake	
<0.001	0.98	0.26	0.00	0.00	1.10	0.03	X84896	P2X purinergic receptor (P2XR) channels bind extracellular ATP and mediate Ca(2+) influx	Liver; ubiquitous
0	1.09	0.16	0.00	0.00	1.15	0.13	U60330	Ki antigen (PA28 gamma); proliferation; the interferon-distribution gamma (IFN-gamma)-inducible PA28 activator complex enhances the generation of class I binding peptides by altering the cleavage pattern of the proteasome	cell Liver, neurons, broad tissue

CYTOSKELETON

P	CR	std	CON	std	SW	std	GenBank	Description	Location
0.022	2.47	0.20	0.00	0.00	1.60	1.35	X05640	NF-M gene for middle-molecular-mass neurofilaments (like keratins)	Epithelial cells (mainly liver and brain)
0.006	1.07	0.19	0.40	0.23	1.09	0.10	ET62211	Formin; reorganization of the cytoskeleton, cytokinesis, stress fiber formation, and transcriptional activation of the serum response factor	the Ubiquitous
0.033	1.42	0.83	0.00	0.00	1.41	0.51	X57377	Myosin heavy chain gene; novel and unique C-terminal region	CNS; cephalic ganglia, and spinal ganglia; lld skeletal myosin heavy chain gene expressed in fat-storing cells (FSC, lipocytes, or Ito cells) of regenerating liver
0.012	1.06	0.07	0.38	0.26	1.22	0.32	ET61336	Nonmuscle myosin heavy chain IIB; cell motility	CNS; lld skeletal myosin heavy chain gene expressed in fat-storing cells (FSC, lipocytes, or Ito cells) of regenerating liver
0.001	1.62	0.35	0.00	0.00	1.12	0.31	M91602	Myosin light chain 2; contractile protein	fat-storing cells (FSC, lipocytes, or Ito cells) of regenerating liver; muscle
0.000	1.90	0.15	0.00	0.00	0.97	0.35	V00830	Epidermal keratin subunit; Liver	(bile duct epithelium, epithelial

P	CR	std	CON	std	SW	std	GenBank	Description	Location
								intermediate filament protein; cells maintenance of epidermal cell shape and resistance to mechanical trauma	
0.001	0.97	0.15	0.48	0.11	1.08	0.07	U58513	Rho kinase (ROCK-2); (Rho is a Ubiquitously expressed except in the small GTPase; serine/threonine brain and muscle protein kinase); Rho activity enhances secretion; phosphorylation of myosin light chain	
0.038	0.97	0.47	0.49	0.02	1.32	0.20	ET61218	Microtubule-associated protein 4 Most cell types including liver (MAP4); co-localizes with microtubules; expressed during developmental; likely involved in differentiation	

TUMOR SUPPRESSORS / ANTI-TUMOR FACTORS

0.006	1.12	0.23	0.35	0.30	1.33	0.19	X97719	Friend-virus-susceptibility-1 gene (Fv1); prevents or delays spontaneous or experimentally induced viral tumors	
0.029	1.77	1.69	0.00	0.00	3.00	0.39	X74671	Neurofibromatosis type 2 gene; Ubiquitous tumor suppressor gene; cytoskeleton-membrane linker; mutant leads to CNS tumors	
0	0.91	0.19	0.00	0.00	1.08	0.06	ET61211	RNA-dependent EIF-2 alpha Ubiquitous kinase; double-stranded (ds) RNA-dependent protein kinase (PKR); key mediator of antiviral effects of interferon (IFN); active player in apoptosis	

FUNCTION UNKNOWN

0	1.23	0.24	0.00	0.00	1.13	0.16	X96737	Synaptobrevin-like gene (SYBL1); Ubiquitous housekeeping gene; X-linked; inactivated on one X in every female cell, and also inactive on the Y of male cells	
0.007	1.35	0.59	0.00	0.00	1.21	0.22	ET62791	WW domain binding protein 6; Uncharacterized WW domain is a globular protein	

P	CR	std	CON	std	SW	std	GenBank	Description	Location
								domain that is involved in mediating protein-protein interaction and that ultimately participates in various intracellular signaling events; WW domain mediates protein-protein interaction by binding proline-rich modules in ligands.	

Low-Hi-Low				Name/Description		Tissue	
p value	CR-ave.	std	Cont-ave	std	Sw-ave	std	GenBank
0.001	0.77	0.20	1.84	0.06	0.73	0.28	M95599
Homeobox-containing protein (Hox-1.11)							
0.001	0.54	0.04	1.85	0.27	0.91	0.28	X58196
Mouse H19 gene: The H19 gene It is expressed at the blastocyst produces an abundant stage of development, and developmentally regulated transcript accumulates to high levels in of unknown function in normal tissues of endodermal and embryos. It is subject to mesodermal origin After birth transcriptional regulation by parental the gene is expressed in all imprinting, which results in the tissues except skeletal muscle. maternally inherited gene being A muscle specific isoform has expressed and the paternally also been cloned inherited gene being repressed.							
0.002	0.89	0.23	2.14	0.46	0.79	0.05	X99807
Selenoprotein P: covalently bound Liver, testis, brain, gut, and 8-12 selenocysteine residue. Its hematopoietic cells concentration is sensitive to the selenium status of the animal. Its function is unknown.							
0.005	1.17	1.26	4.28	0.80	0.75	0.16	J04953
Gelsolin: a Ca ²⁺ and Ubiquitous polyphosphoinositide (PIP2)1-regulated actin filament severing and capping protein that is implicated in actin remodeling in growing and in apoptotic cells							
0.044	0.68	0.78	1.96	0.53	0.33	0.58	L23971
Fragile X mental retardation Brain syndrome protein (Fmr1) (mouse homologue): Fragile X Mental Retardation Syndrome is the most common form of hereditary mental retardation, and is caused by defects in the FMR1 gene. FMR1 is an RNA-binding protein and the syndrome results from lack of							

Name/Description
expression of FMR1 or expression
of a mutant protein that is impaired
in RNA binding. The specific
function of FMR1 is not known

GenBank

Sw-ave std

Cont-ave std

CR-ave. std

Not reported in liver, muscle, brain, blood:

0.032 0.18 0.31 11.84 8.02 0.00 0.00 L02241

Mouse protein kinase inhibitor Testis specific
(testicular isoform): inhibitor protein
of the cAMP-dependent protein
kinase. This isoform of PKI is
reported found only in testis
High-glycine tyrosine keratin type Hair
II.3

0.017 1.24 1.37 4.54 1.85 0.16 0.26 D89901

Blood, T and B cells

0 0.77 0.12 2.89 0.34 1.23 0.42 X14061

Beta-globin complex DNA for γ , Blood
bh0, bh1, b1 and b2 genes, bh2
and bh3 pseudogenes:

0.004 0.29 0.27 3.06 1.00 0.98 0.37 X53247

EN-7: [has 100% seq homology T, B and myeloid hemopoietic
with RAS-related C3 botulinum cells
substrate 2 (Rac2)]: a member of
the ras gene superfamily. mRNA
expression is restricted to the cells
of hemopoietic lineages, mRNA
levels increase with the terminal
differentiation of hemopoietic cells
into granulocytes.

0.008 0.79 0.13 2.15 0.61 0.94 0.18 U09010

Mannose-binding protein A (Mbl1): a Blood
serum protein, a member of a family
of collagenous lectins (collectins),
that activates the complement
system after binding to the
glycoconjugates found on the
surface of microorganism

0.022 0.72 0.05 2.55 0.95 1.21 0.38 M22531

Mouse complement C1q B chain: Macrophages
Mouse complement component C1q

Low-Hi-Low

Tissue

Name/Description
extracellular matrices as well as being abundant plasma proteins. The plasma isoforms of fibronectin, which are synthesized in the adult by liver hepatocytes, differ from those derived from most other cells and tissues due to alternative mRNA splicing

GenBank

Sw-ave std

Cont-ave std

std

p value

Protein Turn-Over / Transport / Processing

0	0.83	0.02	3.40	0.25	1.13	0.38	ET61037	Polyubiquitin: Ubiquitin is an Ubiquitous omnipresent protein found in all eukaryotes so far analysed. It is involved in several important processes, including protein turnover, chromosome structure and stress response
0	0.73	0.12	2.11	0.33	0.98	0.06	X70303	Proteasome subunit MC3 (alpha Ubiquitous type): The proteasome is a multisubunit 20 S proteinase complex involved in ubiquitin-dependent and -independent intracellular protein metabolism.
0.001	0.00	0.00	16.01	3.18	2.78	3.98	D87899	ADP-ribosylation factor 2 (ARF2) Ubiquitous ADP-ribosylation factors (ARFs) are a family of small GTP-binding proteins that are involved in the formation of coated transport vesicles for protein secretion through the endoplasmic reticulum and Golgi vesicular trafficking system
0.063	0.81	0.17	3.06	1.71	1.01	0.29	D78645	Glucose-regulated protein 78 Liver, adipose, brain, heart, kidney, lung, spleen, muscle, small intestine.

Low-Hi-Low
p value CR-ave. std Cont-ave std Sw-ave std GenBank Name/Description Tissue

Signal Transduction
0.004 1.05 0.32 2.48 0.57 0.83 0.09 M13964 Stimulatory G protein of adenylate Ubiquitous
cyclase, alpha chain: component
signal transduction systems.

Transcription Factor
0.037 0.94 0.10 2.14 0.85 0.82 0.24 X57638 Peroxisome proliferator activated Liver
receptor alpha: is activated by a
diverse class of rodent
hepatocarcinogens that causes
proliferation of peroxisomes

Low-Low-Hi					std	SW-ave	Cont-ave	std	GenBank	Name/Description	Tissue
p value	CR-ave	std	Cont-ave	std							
0.013	5.61	9.71	5.11	4.87	18.89	40.81			X04591	Brain creatine kinase B: The creatine kinase-B (CKB) enzyme is proposed to have a pivotal role in the regeneration of ATP in the nervous system.	brain
0.013	1.48	1.77	1.09	0.94	1.34	4.52			M61705	Intestinal alkaline phosphatase (IAP); intestine, (kidney) a membrane-bound metalloenzyme catalysing cleavage of inorganic phosphate nonspecifically from a wide variety of phosphate esters.	
0.015	0.00	0.00	0.01	0.01	8.36	15.52			D78353	Eosinophil peroxidase; is one of the blood (eosinophils) granule enzymes in the eosinophil-specific granules and is distinct from myeloperoxidase.	
0.001	1.12	1.18	0.77	0.66	1.50	6.74			M12930	Erythropoietin; The glycoprotein produced in the kidney or hormone erythropoietin regulates the liver of adult and the liver level of oxygen in the blood by of fetal or neonatal modulating the number of circulating mammals erythrocytes.	
0	0.17	0.29	0.15	0.14	2.34	9.80			J05149	Insulin receptor (IR)	ubiquitous
0.009	0.00	0.00	0.00	0.01	3.82	7.52			U65586	Telomeric protein mTRF1; a telomere ubiquitous repeat binding factor packages the long tandem arrays of the double-stranded TTAGGG sequence motif in mammalian telomeres.	
0.016	0.00	0.00	0.01	0.01	20.11	34.54			X14897	Fos B; a nuclear protein of 338 ubiquitous amino acids presenting a 70% homology with c-fos, whose expression is activated during G0/G1 transition. Similar to c-fos, fos B protein plays a role in control of gene expression.	

Low-Low-Hi				GenBank		Name/Description		Tissue	
p value	CR-ave	std	Cont-ave	std	SW-ave	std	GenBank		
0.005	0.98	0.98	0.66	0.56	3.62	1.12	X66225	Retinoid X receptor-gamma (mRXR-ubiquitous (one isoform in gamma); a kind of nuclear receptors adrenalals, kidney, and of retinoids which play a liver; another in brain and fundamental role in regulating normal lungs; both are expressed cell proliferation and differentiation. strongly in heart and The retinoid X receptors (RXRs) muscle) regulate gene expression by forming transcriptionally active heterodimeric RAR(the retinoic acid receptors)/RXR or homodimeric RXR/RXR complexes on DNA.	
0.023	2.31	3.18	1.84	1.63	16.67	9.38	X54239	Evx1 protein; A murine even-skipped embryos (eve) homologue. During embryogenesis, Evx 1 shows a biphasic expression pattern. The early and late transcription pattern is compatible with a role of Evx 1 in specifying posterior positional information along the embryonic axis and in specifying neuronal cell fates within the differentiating neural tube.	
0.006	0.00	0.00	0.00	0.00	55.35	24.84	X70800	Wnt-11 protein; The Wnt gene family embryos (truncus encodes a set of signalling arteriosus, somites at the molecules, thought to play an medial junction of the important role in key processes of dermatome and the embryonic development. WNT11 has myotome, and limb bud possible roles in the development of mesenchyme) skeleton, kidney and lung.	
0.039	1.10	0.18	0.44	0.57	4.73	3.06	X99796	Tsx; a gene of unknown function testis, that was shown to be expressed specifically in the testis. It locates 3' form the Xist gene which involves in the X inactivation.	

Low-Low-Hi				GenBank		Name/Description		Tissue
p value	CR-ave	std	Cont-ave	std	SW-ave	std	Rds	a eye?
0.043	0.00	0.00	0.01	0.02	15.23	11.16	photoreceptor disc membrane-associated glycoprotein involved in retinal degeneration slow. It is 92.5% identical to the sequence of the bovine photoreceptor-cell protein peripherin. It may function as an adhesion molecule for stabilization of the outer segment discs.	
0	0.99	1.04	0.68	0.59	15.29	2.39	Hepatitis virus MHV-A59 defective ? interfering (DI) RNA; RNA of defective-interfering virus formed earlier in infection, can mediate homologous interference.	

Hi-Hi-Low		Name/Description			tissue		
p value	CR-ave	std	CONT-ave	std	Switched-ave	std	GenBank
0	1.42	0.20	1.17	0.30	0.04	0.07	AF009414
SOX11; Sox genes, which encode ubiquitous transcription factors related by a DNA-binding motif termed the HMG box, are known to have diverse roles in vertebrate differentiation and development. SOX11 was suggested a role in neuronal maturation and an additional role in tissue modelling during development.							
0.041	1.01	0.43	1.21	0.25	0.38	0.23	L40156
surfactant protein D (Sftp4); Surfactant predominantly in lung, and protein-D (SP-D) is a collectin found also in heart, stomach, associated with surfactant in the lung. and kidney but not in brain SP-D has also been functionally characterized as an opsonin for diverse microorganisms and a chemoattractant for phagocytic cells.							
0.013	1.02	0.10	1.26	0.17	0.54	0.29	D86176
Phosphatidylinositol 4-phosphate 5- highly expressed in the kinase-alpha; the type I brain and testis, but barely phosphatidylinositol- 4-phosphate 5- detectable in the liver and kinase (PI4P5K) have been identified as skeletal muscle one of the cytosolic components required for ATP-dependent, Ca2+-activated secretion.							
0.032	1.16	0.33	1.31	0.27	0.61	0.07	Z36293
Sialoadhesin; Sialoadhesin is a expressed strongly by macrophage-restricted adhesion macrophages in lymphoid molecule of 185 kDa that mediates sialic and haemopoietic tissues acid-dependent binding to cells.							

Hi-Low p value	CR- ave	std	CONT- ave	std	Switched-ave	std	GenBank	Name/Description	Tissue
0.001	3.65	0.92	0.32	0.10	1.10	0.33	D83262	Neuronal glutamate transporter induces high-affinity uptake of L-glutamate that is dependent on external Na ⁺ .	Brain (neurons)
0.014	2.73	0.31	0.63	1.09	0.42	0.52	X90778	Histone H2B	retina-specific 1 eye?
0.017	2.25	0.34	0.79	0.74	0.51	0.50	M96760	rod outer segment membrane protein (Rom-1); Rom-1 and peripherin are related retina-specific integral membrane protein localized to the photoreceptor disk rim, where they may act jointly in the photoreceptor disk biogenesis.	
0.018	7.93	4.23	0.00	0.00	1.16	1.25	X14971	alpha-adaptin (A): Adaptins are components of the adaptor complexes which link clathrin to receptors in coated vesicles. The alpha-adaptins, which are found exclusively in endocytic coated vesicles	brain and liver
0.02	7.76	4.74	0.00	0.00	0.00	0.00	D49429	PW29: calcium binding protein with strongly oligoproline motif, a mouse homolog of expressed in the Mcd1pS.c./Rad21S.p., has been implicated testis, brain, functioning in sister chromatid cohesion. kidney and heart	
0.022	10.70	6.08	0.00	0.00	1.38	1.61	M55617	mast cell protease-4: a secretory granule connective tissue serine protease of the peritoneal connective tissue mast cells (CTMC).	
0.023	1.78	0.51	0.84	0.63	0.21	0.31	AFO13253	preprocortistatin (Cort): Cortistatin is a 14-brain residue putative neuropeptide with strong cortical structural similarity to somatostatin and is hippocampus expressed predominantly in cortical GABAergic interneurons. Administration of cortistatin into the brain ventricles specifically enhances slow-wave sleep, presumably by antagonizing the effects of acetylcholine on cortical excitability.	(cerebr. and hippocampus)

Hi-Low-Low		GenBank				Name/Description		Tissue
p value	CR-ave	std	CONT-ave	std	Switched-ave	std	GenBank	
0.032	2.12	0.81	0.73	0.61	0.37	0.39	U02982	secretogranin III (SgIII): an acidic brain- and chromogranin/secretogranin-like protein of pituitary-specific unknown function that is present in the storage vesicles of many neuroendocrine cells.
0.033	1.70	0.28	0.70	0.52	0.54	0.45	U39818	tuberin (TSC2): the tuberous sclerosis 2 ubiquitous (TSC2) gene product, which contains an activity that specifically stimulates the intrinsic GTPase activity of Rap1a and may acts as a presumed tumor-suppressor.
0.037	21.18	14.98	0.00	0.00	0.00	0.00	D17407	U2af1-rs1(SP2); encodes a protein with Ubiquitous significant similarity to U2 small nuclear ribonucleoprotein auxiliary factor small subunits, an essential mammalian splicing factor; an endogenous imprinted gene on the proximal region of chromosome 11. This gene is transcribed exclusively from the unmethylated paternal allele, while the methylated maternal allele is silent.
0.038	16.26	11.58	0.00	0.00	0.00	0.00	X72862	Beta-3-adrenergic receptor; a member of the mainly expressed super-family of G protein-coupled receptors; in mouse plays a role in the control of cAMP and accumulation and may be involved in the adipose tissues control of energy expenditure in fat tissue.
Transcription Factor								
0.007	2.57	0.46	0.70	0.71	0.41	0.52	L10409	Fork head related protein (HNF-3 beta): in Adult liver, addition to its known functions as embryonic node, transcriptional activators in adult liver, play a notochord, floor role in body axis formation, neural tube plate and gut patterning and definitive endoderm formation during gastrulation.

Hi-Low-Low p value	CR- ave	std	CONT- ave	std	Switched-ave	std	GenBank	Name/Description	Tissue
0.007	36.94	12.40	0.00	0.00	6.27	10.87	X86368	Transcription factor FKH-2: a member of the "winged helix" or "forkhead" transcription factor family; expression patterns of the fkh-2 gene and HNF-3 beta, are overlapping in restricted early stages of gestation.	Expressed in and
0	12.24	3.07	0.00	0.00	0.80	1.39	X61754	Heat shock transcription factor 2; binds to the Ubiquitous heat shock element (HSE).	midbrain
0.001	4.43	0.96	0.00	0.00	1.05	0.77	L77247	Zinc finger protein (kid-1); a putative renal transcription factor; regulation during ontogeny and in response to ischemia and toxic injury	Kidney and eye
0.024	16.08	10.27	0.00	0.00	0.00	0.00	X92592	Fkh-5 (also known as Mf3 and TWH); a member of the 'winged helix' or 'forkhead' transcription factor gene family	Specifically expressed in the developing central nervous system
0.007	36.92	17.87	0.13	0.22	0.00	0.00	U66620	SWI/SNF complex 60 KDa subunit (BAF60a); mammalian homologue of yeast SWI/SNF complex; also referred to as BRG1-associated factors (BAFs); facilitates the function of transcriptional activators by opposing chromatin-dependent repression of transcription, and (in mammals) is likely dedicated to developmentally distinct functions.	Ubiquitous
0.005	1.95	0.59	0.87	0.26	0.22	0.17	U83148	NFIL3/E4BP4 transcription factor; nuclear factor regulated by IL-3/adenovirus E4 promoter binding protein in a distinct growth factor-regulated signaling pathway that is responsible for the survival of early B-cell progenitors	Blood

Cell Growth/Cycle

Hi-Low-Low		CR-		CONT-		Switched-		GenBank		Name/Description	Tissue
p value	ave	std	ave	std	ave	std	ave				
0	14.42	3.83	0.00	0.00	0.00	0.00	0.00	L25602		Bone morphogenetic protein 2 (BMP-2); Ubiquitous pleiotropic functions range from extraskeletal and skeletal organogenesis to bone generation and regeneration; structurally related to transforming growth facto-beta s, activins, and inhibins	
0.004	2.97	0.78	0.34	0.60	0.33	0.58		D89080		Fibroblast growth factor 10 (FGF10): has expressed important roles in mediating mesenchymal-relatively epithelial cell interactions during abundantly in embryogenesis. In particular, Fgf10 is embryos and the predicted to function as a regulator of brain, lung, and at lung and limb development, prostatic growth much lower and development and so on.	
0.002	14.09	4.67	1.12	1.93	0.00	0.00		M30903		B lymphocyte kinase (blk); a Src family Blood (specifically tyrosine kinase specific to B lymphoid cells expressed in the B cell lineage)	
0.007	4.14	1.40	0.00	0.00	1.09	1.14		X59398		Tyrosine kinase receptor of the various adult PDGFR/CSF1R family (Flt-3); involved in tissues including development and function of various cell gonads and brain, lineages; unidentified ligand in placenta, and in gonads and hematopoietic and nervous hematopoietic systems.	
0.008	1.64	0.34	0.00	0.00	0.71	0.62		U22399		Cdk-inhibitor p57KIP2 (KIP2); a potent, tight-High binding inhibitor of several G1 cyclin/Cdk expression in complexes; and is suggested to be involved skeletal muscle, in decisions to exit the cell cycle during brain, heart, development and differentiation..	
Extracellular Matrix											
0.023	24.61	5.47	0.00	0.00	7.30	12.64		M32136		alpha-1 type IX collagen (COL9A1): a ubiquitous structural component of the extracellular matrix of connective tissues	

Hi-Low-Low p value	CR- ave	std	CONT- ave	std	Switched-ave	std	GenBank	Name/Description	Tissue
0.035	2.93	1.06	0.64	1.10	0.81	0.21	U43541	s-laminin (also called laminin beta 2): a muscle homologue of the B1 (beta 1) chain of the widely distributed basal lamina (BL) glycoprotein, laminin. It may affect postsynaptic differentiation.	
DNA repair									
0.039	14.29	8.65	0.00	0.00	2.67	3.79	L26320	FLap endonuclease-1 (FEN-1): an enzyme Ubiquitous which functions in double-strand break repair flap resolution; it specifically cleaves DNA flap strands that terminate with a 5' single-stranded end; in addition to endonuclease activity, FEN-1 has a 5'-3' exonuclease activity which is specific for double-stranded DNA.	

Low-Hi-Hi p value	CR- ave	CR- std	Cont- ave	Cont- std	SW- ave	SW- std	GenBank	Name/Description	Tissue
0.005	0.46	0.08	1.07	0.27	1.22	0.14	L11333	Mouse carboxyesterase; dependent enzymes	serine- Predominantly in male livers
0.049	0.51	0.45	1.18	0.06	1.06	0.14	M74149	Creatine kinase B; plays an important role in buffering ATP and ADP levels in tissues which have intermittently high and fluctuating energy demands	liver, brain, skeletal muscle, intestines
0.014	0.56	0.06	1.16	0.25	1.27	0.27	M17122	Complement 4b-binding protein (C4b-binding protein);an abundant oligomeric plasma glycoprotein which controls the activation of the complement cascade through the classical pathway	
0.02	0.30	0.39	1.16	0.32	1.38	0.34	U36393	TFEB; a member of the Liver, microphthalmia-TFE (MiT) subfamily of basic helix-loop-helix leucine zipper transcription factors.	brain, skeletal muscle, lung, kidney,
0.025	0.58	0.11	1.09	0.31	1.28	0.25	D70849	Zic3; encodes a zinc finger protein, expressed in the developing or the adult stage. matured central nervous system in a highly restricted manner.It's the vertebrate homologue of Drosophila odd-paired, which may play an essential role in parasegmental subdivision and in visceral mesoderm development.	
0.046	0.50	0.21	1.37	0.35	1.49	0.57	D37837	65-kDa macrophage cytosolic protein; is phosphorylated specifically in LPS-stimulated murine macrophages. a murine homologue of human L-plastin, recently identified as a novel transformation-induced polypeptide of neoplastic human cells. Its function is implicated in macrophage activation by LPS.	Hemopoietic cells

APPENDIX G

208 known genes: 2-fold or greater in CR vs. Cont at old and young age

GenBank	Description	Location
Transcription Factor / Nuclear Receptor		
Y00850	Zinc finger protein 2 (Zfp2); Mkr-2; differentiation and/or maintenance of neurons	Brain (Central and peripheral neurons)
X63963	Paired box protein (Pax-6); transcription factor	Developing CNS
X06762	Homeo box B7 (Hoxb7); transcription factor; embryonic development; haematopoiesis;	Developing embryo; blood; bone marrow cells; natural killer cells
X74040	Homeo box A9 (Hoxa9); transcription factor	Embryogenesis
X59251	Homeo box msh-like 1 (Msx1); transcription factor; early stage of eye developmental regulation in embryo	Embryogenesis
Z67747	Zinc finger protein 62 (Zfp62); a member of a multigene family encoding Zn mediated nucleic acid binding proteins	Embryonic development and Skeletal, cardiac muscle, and spleen in adult
M36516	Zinc finger protein 28 (Zfp28); a member of a multigene family encoding Zn mediated nucleic acid binding proteins	Embryonic development, testes in adult
U48721	Zinc finger protein 60 (Zfp60); a member of a multigene family encoding Zn mediated nucleic acid binding proteins; Kruppel associated boxes; associated with transcriptional control	Expressed transiently during muscle differentiation
X04435	Glucocorticoid receptor 1 (Gr1); energy balance; substrate uptake; liver	Liver
X74134	Nuclear receptor subfamily 2, group F member 1 (Nr2f1); COUP-TF1; orphan steroid hormone receptor; transcription factor	Liver
D00925	Transcription elongation factor A 1(Tcea1); transcription elongation factor	Liver
X89264	Zinc finger protein 37 (Zfp37); putative transcription factor; peroxisome proliferator responsive	Liver
X56182	Myogen factor 5 (Myf5); transcription factor	Liver and heart (embryonic)

208 known genes: 2-fold or greater in CR vs. Cont at old and young age

GenBank	Description	Location
X76653	Nuclear receptor subfamily 2, group F member 2 (Nr2f2); apolipoprotein regulatory protein 1; member of the COUP-family of steroid hormone orphan receptors	Liver, lung, kidney
L24118	Tumor necrosis factor induced protein 2 (Tnfp2); putative transcription factor	Liver; monocytes
U36575	Nuclear factor of activated T cells, cytoplasmic 2 (Nfatc2); T cell transcription factor isoform	Lymphocytes
U19463	Tumor necrosis factor induced protein 3 (Tnfp3); putative helix-loop-helix transcription factor activated in T-cell acute lymphoblastic leukemia	Lymphocytes
U19463	Tumor necrosis factor induced protein 3 (Tnfp3); putative helix-loop-helix transcription factor activated in T-cell acute lymphoblastic leukemia	Lymphocytes
ET61028	Sine oculis-related homeobox 1 homologue (Drosophila) (Six1); AREC3	Many cell-types during development
U13878	RE1-silencing transcription factor (Rest); transcription factor; represses expression of neuronal genes;	Many nonneuronal cells and tissues
Y12293	Forkhead box F2 (Foxf2); transcription factor; a developmental regulator in embryonic development	Mesodermal tissues and embryonic: central nervous system, eye, ear, and limb bud
X60034	Homeo box D1 (Hoxd1); transcription factor; neurogenesis	Neurogenesis
ET63177	Pax-4 (Pax4); a paired-box transcription factor that plays an important role in the development of pancreatic beta/delta cells; role in endocrine cell development	Pancreatic islet endocrine progenitor cells
M81077	T-cell acute lymphocytic leukemia 2 (Tal2); putative basic helix-loop-helix transcription factor activated in T-cell acute lymphoblastic leukemia	T cells
X72697	Meiosis-specific XMR (Xmr); transcriptional activator function?	Testis; lymphoid cell lineages; nuclei of spermatocytes, early in the prophase of the first meiotic division, and later becomes concentrated in the XY nuclear subregion
X76858	E4F transcription factor 1 (E4f1); DNA binding transcription factor	Ubiquitous

208 known genes: 2-fold or greater in CR vs. Cont at old and young ages

GenBank	Description	Location
X15842	Reticuloendotheliosis (Rel); c-rel: member of the Rel/nuclear factor (NF)-kappaB family of transcriptional factors	Ubiquitous
X60136	Trans-acting transcription factor 1 (Sp1); transcription factor; component of some hepatic glucose response elements	Ubiquitous
X80508	Yes-associated protein, 65 kDa (Yap); transcription activator	Ubiquitous
ET61461	G-protein coupled receptor; poorly characterized	Unknown
<u>Translation / Splicing / RNA Processing Factors</u>		
Y08260	Cytoplasmic polyadenylation element binding protein (Cpeb); RNA binding protein that promotes polyadenylation and translational activation	Ubiquitous
X91656	Splicing factor arginine/serine-rich 3 (Sfrs3); splicing factor belonging to the highly conserved family of SR proteins; regulation of constitutive and alternative splicing	Ubiquitous
U28419	Translation initiation factor eif-4C homologue	Ubiquitous
<u>Signal Transduction / Cell Cycle and Growth</u>		
L28756	Gonadotropin releasing hormone receptor (Gnhr); G-protein-coupled receptor; activates MAPK cascades	Brain (anterior pituitar), reproductive organs
Z31663	Activin A receptor, type 1B (Acvr1b); serine/threonine kinase receptor; a downstream transducer of activin signals	Brain (cerebral cortex, olfactory tubercle, and hippocampus)
X66118	Glutamate receptor, ionotropic, kainate 1 (Grik1)	Brain (CNS)
L41495	Provirial integration site (Pim2); serine/threonine kinase 2; cell proliferation; mitogen stimulated; long-term potentiation in hippocampus	Brain (CNS), Immune and epithelial cells
Z72000	B-cell translocation gene 3 (Btg3); negative control of cell cycle	Brain, fibroblast

208 known genes: 2-fold or greater in CR vs. Cont at old and young age

GenBank	Description	Location
X79082	Eph receptor A7 (Epa7); developmental kinase 1; member of receptor tyrosine kinase family	Brain, testes and spleen
Z27088	Relaxin (Rln); insulin gene family; remodeling of collagen	Brain, uterus, prostate gland, pancreas and kidney
X58287	Protein tyrosine phosphatase, receptor-type, M (Ptpm)	Capillaries in developing neural tissue, lung;
ET61628	Phosphatidylinositol 3-kinase regulatory subunit, polypeptide 1 (p85alpha) (Pik3r1); role in cell growth, differentiation, survival, and vesicular transport	Liver
V00829	kallikrein 6 (Klk6); a member of multigene subfamily of serine protease that act on a diverse number of substrates, including several growth factors and extracellular matrix glycoproteins and proteinases;	Liver
Z22821	Rab23; Ras-related small GTPase; protein trafficking; central regulatory elements of the intracellular transport machinery; regulate vesicle docking and fusion, organelle dynamics	Liver
M25513	Guanine nucleotide binding protein, alpha transducing 1 (Gnat1)	Liver and others
M63658	Guanine nucleotide binding protein beta 4 (Gnb4)	liver, brain, blood cell
U38501	Guanine nucleotide binding protein, alpha inhibiting 1 (Gnai1)	Liver; cerebral cortex; pancreatic acinar cells; white adipose tissue; others
D30743	Wee1 homologue (S. pombe) (Wee1); inhibits entry into mitosis by phosphorylation of the Cdc2 kinase	Lymphocytes
ET61263	Spleen protein kinase (Syk); signal transduction	Lymphopoiesis; haematopoietic cells, platelets, macrophages and neutrophils
Z48757	Intestinal tyrosine kinase; protein tyrosine kinase	Mammary gland and intestine
ET61665	Discs-large tumor suppressor homologue (dlgh1); important role in the localization and function of glutamate receptors and K(+) channels	Neurons; epithelial cells
ET61399	G protein alpha olfactory subunit; sensory transduction	Olfactory epithelium
M14537	Acetylcholine receptor beta (Acrb)	Skeletal muscle

	Description	Location
X92523	Calpain 3 (Capn3); intracellular calcium-dependant cysteine proteinase; tissue specific myofibrinogenesis, modifies ryanodine/receptor Ca2+ release channel	Skeletal muscle
Z11574	Son of sevenless 1, homologue 1 (Drosophila) (Sos1); Ras-specific exchange factor	T cells
Z11664	Son of sevenless 2 homologue 2 (Drosophila) (Sos2); Ras-specific exchange factor	T cells
U10440	Cyclin-dependent kinase inhibitor 1B (P27) (Cdkn1b); cell cycle	Ubiquitous
ET61257	MAP kinase kinase kinase (Map3k1); serine-threonine kinase; regulates sequential protein phosphorylation pathways involving mitogen-activated protein kinases (MAPKs)	Ubiquitous
S45828	NIMA-related expressed kinase (Nek1)	Ubiquitous
U65313	Ras-GTPase-activating protein SH3-domain binding protein 2 (G3bp2-pending); essential for Ras signaling;	Ubiquitous
ET62740	Ankyrin 3 (Ank3); implicated in Na(+) channel clustering and activity; neuronal axons	Wide distribution

Hormone/Growth Factor/Cytokine/Chemokine

X07962	Interleukin 7 (IL-7); growth factor	B cell progenitors
U66201	Fibroblast growth factor homologous factor 1 (FGF-1); nervous system development and function	Brain, skeletal muscle and other
U66204	Fibroblast growth factor homologous factor 4 (FHF-4); involved in nervous system development and function	Brain (CNS)
X99572	C-fos-induced growth factor (FIGF); secreted dimeric protein member of the platelet-derived growth factor/vascular endothelial growth factor (PDGF/VEGF) family; mitogenic and morphogenic activity on fibroblasts.	Endothelial cells, expressed in many tissues (including liver) during embryonic development
J00424	Interferon-beta	Liver
X07751	Thyroid hormone receptors	Liver
ET62118	Keratinocyte growth factor/fibroblast growth factor-7 precursor (mKGF)	Liver epithelial cells

208 known genes: 2-fold or greater in CR vs. Cont at old and young age

GenBank	Description	Location
X57413	Transforming growth factor-beta2 (TGFbeta2); cell proliferation	Liver stellate cells
ET62976	Macrophage inflammatory protein receptor 1-alpha 2; Induces mobilization of intercellular calcium; beta-chemokine; leucocyte chemoattractant	Liver, brain, thymus, heart, spleen
X53798	Small inducible cytokine subfamily, member 2 (Scyb2)	Macrophages
V00428	Lysozyme; signaling molecule for mast cells which respond with histamine secretion	Macrophages, paneth cells (located in duodenal crypts)
ET61471	Mast cell protease 7 (mMCP-7); mouse mast cell tryptase 2; released when mast cells are activated	Mast cells
U28404	Macrophage inflammatory protein-1 alpha receptor; mediates growth inhibitory effects of the chemokine	MIP-1alpha RL2 in liver and spleen
U58367	Neuropeptide Y receptor Y5/Y6/Y2b (referred to as both Y5 and Y2b, has now been designated as Y6 in literature); (NPY-Y6); neuropeptide Y is an important regulator of energy balance in mammals through its orexigenic, antithermogenic, and insulin secretago	Neurons, vascular smooth muscle cells
U10092	Killer cell lectin-like receptor, subfamily A, member 6 (Klra6); Ly-49F; NK cell surface antigen; determinant of IL-2-activated NK cell specificity; inhibitory receptor for interaction with MHC class I proteins	NK cells
M31419	Interferon-activatable gene (204); mediates antimicrobial, immunomodulatory and cell growth-regulatory activities of interferons; increased up to 75-fold by alpha-interferon treatment	Nucleoli
X04725	Preproinsulin gene I	Pancreas and islets
X04724	Preproinsulin gene II	Pancreas and islets
M92416	Fibroblast growth factor (Fgf6); Fgf6 is the only known member of the FGF family whose expression is restricted to the muscle cell lineage during development	Skeletal muscle
X58995	Calmodulin-dependent protein kinase IV; multifunctional, serine-threonine protein kinase	T cells
V00756	Interferon beta (type 2)	T cells
M26271	Interleukin 2 receptor; cytokine receptor	T cells

208 known genes: 2-fold or greater in CR vs. Cont at old and young age

GenBank	Description	Location
D13695	Lymphocyte antigen 84 (Ly84); signal transduction protein 2	T cells
M28587	Alpha leukocyte interferon (MULFN-alpha A); inhibition of cell proliferation	Ubiquitous
U49866	killer cell lectin-like receptor, subfamily A, member 3 (Klra3); interact with MHC class I (MHC-I) molecules on target cells	natural killer cell
<i>DNA Replication / Repair / Apoptosis</i>		
L31532	Bcl-2-beta; suppresses programmed cell death	Liver
Z37110	Cyclin G; augments apoptosis; target gene of P53	Liver
U25691	Lymphocyte specific helicase; putative role in replication, repair, recombination and transcription	T and B cells
L15435	Tumor necrosis factor (ligand) superfamily, member 9 (Tnfsf9), a member of the TNF family; proapoptosis factor	T cells
ET62746	Brca2 gene; familial breast cancer susceptibility gene; important in DNA double-strand break repair (DSBR) and DNA damage-induced cell-cycle checkpoint activation	Ubiquitous
U04269	Caspase 1 (Casp1); cysteine protease mediator of apoptosis	Ubiquitous
X58472	KIN17, DNA-binding, nuclear protein, upregulated in response to UV and ionizing radiation; accumulated in the nucleus of proliferating fibroblasts; overexpression inhibits progression into S phase	Ubiquitous
ET63479	MLH1; DNA mismatch repair gene; function in mutation avoidance; cell cycle checkpoint control; cytotoxicity of various DNA-damaging agents; transcription-coupled nucleotide excision repair.	Ubiquitous
ET61211	RNA-dependent EIF-2 alpha kinase; double-stranded (ds) RNA-dependent protein kinase (PKR); key mediator of antiviral effects of interferon (IFN); active player in apoptosis	Ubiquitous

GenBank	Description	Location
X74351	XPAC (Xeroderma Pigmentosum group A Correcting protein); nucleotide excision DNA repair	Ubiquitous
X71978	Ft1, a novel gene related to ubiquitin-conjugating enzymes; deletion leads to partial syndactyly of the limbs and thymic hyperplasia, suggesting impaired programmed cell death	

Transporter / Channel / Pumps

Y09108	sodium channel, type X, alpha polypeptide (Scn10a); ion channel; small-diameter sensory neurons associated with unmyelinated axons express a tetrodotoxin-insensitive (TTXi) voltage-gated sodium channel (VGSC); may play an important role in the transmission of nociceptive information	Brain
U14420	gamma-aminobutyric acid (GABA-A) receptor, subunit beta 3 (Gabra3); link binding of GABA (gamma-aminobutyric acid) to inhibitory chloride flux	Brain (CNS)
U48397	Mercurial-insensitive water channel 1 (mMIWC1); allows water and small solutes to pass	Brain, eye, lung, kidney, heart, muscle
X97281	K + channel beta-subunit, ion channel	Brain, Kidney
ET61590	Putative capacitative calcium entry channel (Trp6); involved in calcium entry secondary to activation of receptors coupled by the Gq class of G protein.	Brain, kidney, heart and lung
X63100	Gap junction membrane channel protein alpha 7 (Gja7); connexin45; gap junction protein; ion exchange channel	Brain, lung, brain, heart, intestine, kidney
ET63385	Gap junction membrane channel protein beta 6 (Gjb6); connexin 30; forms transmembranous gap junction channels between adjacent cells	Brain; skin
L42340	Sodium channel 27	Brain; tissue distribution and protein poorly characterized
ET61440	Trp-related protein 3; cation channel; essential for agonist-activated capacitative Ca2+ entry; putative subunits of CCE channels	Endothelium
M23383	Glucose transporter 2	Liver
D29797	Syntaxin 3A, IER vesicular transport, membrane fusion	Liver

GenBank	Description	Location
X83933	Ryanodine receptor type 2; form Ca ²⁺ channels in the membrane of the ER; intracellular calcium release channels controlling cytosolic calcium levels.	Liver, neuron, cardiac muscle
ET62883	Skeletal muscle chloride channel	Skeletal muscle
X80417	MB-IRK2 (second class of inward rectifier potassium channels); ion channel	Skeletal muscle, heart, kidney
M30440	Potassium channel gene (MK2); shaker subfamily	T cells; myelinating Schwann cells
U03723	AKR voltage-gated potassium-channel (KCNA4)	Ubiquitous
U49393	ATPase (Atp2a3); Ca ²⁺ + transporting, ion pump	Ubiquitous
X84896	Purinergic receptor P2X, ligand-gated ion channel 1 (P2rx1); mediate Ca ²⁺ influx; liver, ubiquitous;	ubiquitous
ET63248	RAN binding protein 1 (RANBP1); RAN-specific GTPase-activating protein; required for nucleocytoplasmic transport of many types of cargo	Ubiquitous
U19521	Vesicle transport protein (munc-18c)	Ubiquitous

Chromatin Structure

J03482	Histone H1; chromatin structure	Ubiquitous
ET62262	Histone H1b; chromatin structure	Ubiquitous
X16495	Histone H2A; chromatin structure	Ubiquitous
ET62908	Histone H2B; chromatin structure	Ubiquitous
U62672	Histone H3.1-D (H3-D) and histone H4-D (H4-D); chromatin structure	Ubiquitous
U62675	Histone H3.2-616, and histone H2b-616; chromatin structure	Ubiquitous
U62669	Histone H3.2-F (H3-F), histone H2a.1-F (H2a-F), histone H2b-F (H2b-F); chromatin structure	Ubiquitous

Biosynthesis and Metabolism

X92122	UDP-glucuronosyltransferase 8 (Ugt8); key enzyme in cerebroside and sulfatide biosynthesis; glycosphingolipids; most abundant in myelin	Brain (CNS and PNS); tissue distribution poorly
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208 known genes: 2-fold or greater in CR vs. Cont at old and young age

GenBank	Description	Location
Y12257	Glutamic acid decarboxylase 67 kD; a rate-limiting enzyme in the biosynthesis of the neurotransmitter, gamma-aminobutyric acid (GABA)	Brain (CNS)
D49438	25-hydroxyvitamin D3 24-hydroxylase; metabolism and regulation of vitamin D3	Kidney and intestine.
X07888	3-hydroxy-3-methylglutaryl coenzyme A reductase; key regulatory enzyme for cholesterol biosynthesis.	Liver
D21826	Cytidine monophospho-N-acetylneuraminic acid hydroxylase; the key enzyme for the synthesis of N-glycolylneuraminic acid (NeuGc)	Liver
U00932	Glutamine fructose-6-phosphate transaminase 1 (Gfpt1); rate-limiting enzyme in hexosamine synthesis	Liver
L39373	Mannoside acetyl glucosaminyl transferase 3 (Mgat3); transfers the bisecting GlcNAc to the core of complex, N-linked carbohydrates	Liver
X72959	N-acetyl transferase 3 (Nat3)	Liver
J00355	Alpha-amylase-1; glycogen digestion and mobilization	Liver and salivary glands
J04947	Angiotensin converting enzyme (Ace); dipeptidyl carboxypeptidase that converts angiotensin I into the potent vasoconstrictor angiotensin II	Liver, brain
L09105	Glucose phosphate isomerase (GPI); a housekeeping gene expressed in all tissues and organisms that utilize glycolysis and gluconeogenesis.	Ubiquitous
ET62525	Polypeptide N-acetylgalactosaminyltransferase-T4 (polypeptide GalNAc transferase-T4; ppGalNAse-T4); fourth member of the mammalian UDP-GalNAc; Golgi-like localization; 4 GalNAc-transferase controls the initiation of mucin-type O-linked protein glycosylation	Ubiquitous
X14489	Thymidylate synthase (Tyms)	Ubiquitous (all proliferating cells)
U34071	Galactosidase, alpha (Gla); carbohydrate metabolism	Ubiquitous (most cases)

Cellular Component (cell adhesion / membrane components / extracellular matrix)

GenBank	Description	Location
ET62381	K-cadherin/cadherin-6; present at external cell surface at cell-cell contact sites; calcium-dependent cell adhesion molecule	Brain (cerebral cortex in neonatal mice), thymocytes
X95226	Dystrobrevin (Dtn); formation and maintenance of mammalian neuromuscular junction	Brain (CNS)
X07215	Proteolipid protein (Plp), main integral protein of myelin	Brain (CNS)
ET61336	Nonmuscle myosin heavy chain IIB; cell motility	Brain (CNS)
ET63017	Cadherin 8 (Cdh8); adhesion molecule	Brain (subdivision of early CNS) and thymus
X57377	Myosin Va (Myo5a); cytoskeleton	CNS, cephalic ganglia, and spinal ganglia; Ild skeletal myosin heavy chain gene expressed in fat-storing cells (FSC, lipocytes, or Ito cells) of regenerating liver
X66976	Procollagen, type VIII, alpha 1 (Col8a1); extracellular matrix; component of basal laminae	Epithelial, endothelial, and mesenchymal cells in newborn mouse tissue
M91602	Myosin light chain, phosphorylatable, cardiac ventricles (MyIpc); contractile protein, cytoskeleton	fat-storing cells (FSC, lipocytes, or Ito cells) of regenerating liver; muscle
ET63188	Fibroblast activation protein; cell-surface glycoprotein; member of the serine protease family; expressed at sites of tissue remodelling.	Fibroblasts
M17376	Alpha-1-acid glycoprotein 1 (AGP-1); membrane protein	Liver
U49185	Occludin (Ocln); occludin is a transmembrane protein located at tight junctions and is known to interact with other tight junction proteins	Liver
L02918	Procollagen type V alpha 2	Liver
V00830	Epidermal keratin subunit; intermediate filament protein; maintenance of epidermal cell shape and resistance to mechanical trauma	Liver (epithelial cells)
X53176	Integrin alpha 4 (Itga4); cell adhesion	Lymphocytes
X91043	Erythrocyte protein band 7.2 (Epb7.2); stomatin; involved in Na ⁺ /K ⁺ permeability of cells	Spleen, lung, testis, not reported in liver
U69136	Cadherin 9 (Cdh9); calcium-binding membrane glycoprotein; cell adhesion molecule	Thymocytes
X97227	CD53 antigen (Cd53); pan-leukocyte antigen; cell membrane glycoprotein	Thymocytes

208 known genes: 2-fold or greater in CR vs. Cont at old and young age

Description

GenBank

Ubiquitous

X75636	Iduronato-2-sulfatase (Ids); degrades heparin sulfate and dermatan sulfate in lysosomes; deficiency causes fatal lysosomal storage disorder, mucopolysaccharidosis type II (the glycosaminoglycans heparin sulfate and dermatan sulfate accumulate); part of proteoglycans which bind, help package and store secretory molecules; function in cell adhesion and basal lamina formation	Ubiquitous
X66402	Matrix metalloproteinase 3 (Mmp3); extracellular matrix-degrading metalloproteinase	Ubiquitous
U56734	Mannose receptor, C type 2 (Mrc2); cell adhesion; antigen presentation	Wide tissue distribution

Cell surface receptor

D78175	Natriuretic peptide receptor 3 (Npr3); membrane protein; modulates availability of natriuretic peptides at target organs; activation of G protein-coupled signaling system;	Epithelial and endothelial cells; lung (smooth muscle cells), heart (aortic smooth muscle cells)
M61000	Gastrin releasing peptide receptor (Grpr); member of the G protein-coupled receptor family	Fibroblasts
M35684	Complement receptor 2 (Cr2)	Late pre-B cells
ET61559	Bradykinin B1 subtype receptor; G protein-coupled membrane bound; T-kininogen modulation during acute phase protein synthesis	Liver (ubiquitous)
M86441	Fibroblast growth factor receptor 2 (Fgfr2); membrane-spanning tyrosine kinase; activated by three members of the FGF family	Liver parenchymal cells and others
U57612	CD44 antigen (Cd44); receptor for hyaluronan; cell surface glycoprotein; hyaluronan clearance from the blood; lymphocyte homing and activation	liver, CNS, other
ET61693	Leptin receptor (OB-R); transmembrane receptor	Liver, Lung, muscle, brain; developing bone, mesenchyme

GenBank	Description	Location
ET62920	CC Chemokine Receptor-4; integral membrane protein; G-protein coupled receptor; signals involve chemotaxis and calcium flux; directs cell movement in thymus; directs monocytes and lymphocytes to their target tissues	Thymus, T cells, and monocytes
<u>Molecular Motors:</u>		
ET63395	Axonemal dynein heavy chain (mdhc1); axonemal dyneins are molecular motors that drive the beating of cilia and flagella; heavy chains are main components of multisubunit motor ATPase complexes called dyneins	Brain, trachea, testis
ET63399	Axonemal dynein heavy chain (mdhc3); axonemal dyneins are molecular motors that drive the beating of cilia and flagella; heavy chains are main components of multisubunit motor ATPase complexes called dyneins	Brain, trachea, testis
ET63402	Axonemal dynein heavy chain (mdhc6); axonemal dyneins are molecular motors that drive the beating of cilia and flagella; heavy chains are main components of multisubunit motor ATPase complexes called dyneins	Brain, trachea, testis
ET63405	Axonemal dynein heavy chain (mdhc9); axonemal dyneins are molecular motors that drive the beating of cilia and flagella; heavy chains are main components of multisubunit motor ATPase complexes called dyneins	Brain, trachea, testis
ET62103	Nebulin; a family of giant myofibrillar proteins	

Serum Protein/Secreted Protein

208 known genes: 2-fold or greater in CR vs. Cont at old and young age

GenBank	Description	Location
V00743	Alpha fetoprotein (Afp); main component of mammalian fetal serum; synthesized by visceral endoderm of the yolk sac and by fetal liver; blood level decreases after birth; synthesis reactivated in liver tumors	Liver (fetal & adult)

Immune Cell Function / Primary Response Genes

M88242	prostaglandin-endoperoxide synthase 2 (Ptgs2); putative mediator of inflammation; induced by growth factors and cytokines	Fibroblasts and monocytes
L38281	Immunoresponsive gene 1(lrg1); activated by bacterial LPS treatment	Macrophages
U43384	Cytochrome b-245, beta polypeptide (Cybb); a flavocytochrome that mediates the transfer of electrons from NADPH to molecular oxygen in the respiratory burst oxidase	Phagocyte
Y08026	Immunity-associated protein, 38 kDa (Imap38)	Spleen
X15592	Cytotoxic T lymphocyte-associated protein 2 beta (Ctla2b); homologue of cysteine protease proregion;	T cells

Others

ET62336	DNA ligase III-beta; DNA ligase III exists as two distinct isoforms denoted alpha and beta	Alpha is expressed in most tissues; beta is expressed in testes and during spermatogenesis
X61449	nucleosome assembly protein 1-like 1	Brain; expression poorly characterized
L28819	Involucrin (Ivl); a glycine-,serine- and cysteine-rich protein expressed late in differentiation of granular layers in normal epidermis	Epidermis
X99251	Repetin (Rptn); calcium-binding; similar to intermediate filament-associated proteins profilaggrin and trichohyalin; expression during late epidermal differentiation	Epithelia of forestomach and tongue

ET61424

Protein-tyrosine phosphatase epsilon precursor; the protein tyrosine phosphatase epsilon (PTPepsilon) gene gives rise to two proteins: a transmembranal, receptor-like form and a cytoplasmic, non-receptor form

U73915

Phosphate regulating neutral endopeptidases on the X chromosome (Phex); mineralization of extracellular matrix by osteoclasts

Kidney, bone

ET61364

Meprin beta subunit isoform (Mep-1beta); meprins are membrane-bound oligomeric metalloendopeptidases, contain alpha and/or beta subunit

Kidney, intestine, not reported in liver

U60330

Proteaseome 3 (Psme3); Ki antigen; cell proliferation; enhances generation of class I binding peptides;

Liver, neurons, broad tissue distribution

X16490

Plasminogen activator inhibitor , type II (Planh2); serine protease inhibitor; inactivates urokinase-type plasminogen activator and regulates degradation of the extracellular matrix; one form is cytoplasmic the other is translocated into the endoplasmic reticulum

Liver; bone-marrow, spleen, lung, thymus, skin

X58169

T-complex protein 10a (Tcp10a); Tcp-10 gene has been established as a molecular candidate for the T complex responder locus which plays a central role in the transmission ratio distortion phenotype expressed by males heterozygous for a T haplotype.

Male germ line

Z46299

Sperm autoantigenic protein 17 (Sp17); sperm specific protein; calmodulin binding protein

Mammalian testis; sperm-specific

M26940

Casein beta (Csnb); milk protein

Mammary glands

ET63259

Cea14 gene (carcinoembryonic antigen family members); unknown function; member of the immunoglobulin superfamily

Many cea genes expressed in fetal liver

ET63260

Cea15 gen (carcinoembryonic antigen family members); unknown function; member of the immunoglobulin superfamily

Many cea genes expressed in fetal liver

208 known genes: 2-fold or greater in CR vs. Cont at old and young age

GenBank	Description	Location
ET63261	Cea16 gene (carcinoembryonic antigen family members); unknown function; member of the immunoglobulin superfamily	Many cea genes expressed in fetal liver
M20567	Heat shock protein, 70 kDa 2 (Hsp70-2); not induced by heat shock; developmentally regulated in P60spermatogenic cells; critical role in spermatogenesis	Meiotic phase of spermatogenesis
X04405	Myoglobin (Mb); small globular heme protein; oxygen-carrying	Muscle
ET63205	Odorant binding protein lb	Nasal epithelium.
ET63156	Disabled homolog 1 (Drosophila) (Dab1); adaptor molecule in neural development	neuronal and hematopoietic cells
ET62968	Odorant receptor 23 (OR23)	Olfactory and testicular cells
U96701	Serine protease inhibitor 15 (Spi15); regulator of extracellular proteolysis	Predominantly in testis
ET63408	Capping protein beta 3 subunit; a novel isoform of actin-binding protein; a component of the cytoskeletal calyx of the mammalian sperm head.	Spermiogenesis
ET62832	Perforatorial protein (PERF 15); a novel testicular protein; sequence similarities to a family of lipid binding proteins; major component of the rat sperm perinuclear theca.	Testis
Z38118	Synaptonemal complex protein 1 (Sycp1); pairing of chromosomes during meiosis	Testis
M19413	Tubulin alpha, related sequence 1 (Tuba-rs1)	Testis
Y08485	Synaptonemal complex protein 3 (Sycp3); part of the lateral element of the synaptonemal complex; a meiosis-specific protein structure essential for synapsis of homologous chromosomes	Testis; synaptonemal complex protein 1 is also expressed in embryonic ovary, adult brain and testis
X96737	Synaptonemal complex protein 1 (Syb1); housekeeping gene; X-linked; inactivated on one X in every female cell, and also inactive on the Y of male cells	Ubiquitous
X92842	Surfeit gene 6 (Surf6); involved in a nucleolar ribosome maturation; housekeeping	ubiquitous (nucleolus)

GenBank	Description	Location
ET62791	WW domain binding protein 6; WW domain is a globular protein domain that is involved in mediating protein-protein interaction and that ultimately participates in various intracellular signaling events; WW domain mediates protein-protein interaction by bin	Uncharacterized
ET62978	Neosin/lark; RNA-binding protein; Drosophila homologue encodes an element of the clock output pathway regulating adult eclosion (circadian rhythm)	Uncharacterized, probably neuronal

142 known genes: 2-fold up in young CR vs young Control and unchanged in old CR vs old Control

<i>t-test</i>	<i>ng t-test</i>	Bank	notype	ation
		Bank		
0.083	0.001	854	troglycan (Dag1); Dystrophin associated protein 1; acts as a receptor for element membrane components	cle, epithelial cells (liver and others)
0.070	0.000	664	rin A5 (Efna5); Eph-related receptor sine kinase ligand 7; LERK-7; AL-1; S; essential for proper axon guidance and graphic mapping	ryo visual system, CNS and peripheral nervous system
0.084	0.014	122	assium inwardly-rectifying channel, family J, member 6 (Kcnj6) ; G protein- vated; play a role in resting potential and trolling excitability of the cell	rons
0.425	0.008	135 and 861	tin receptor (Lepr); Obr; leptin is a key ght control hormone; mutation of the leptin ptor causes obesity	r, ubiquitous, but not in thymus or pancreas
0.346	0.008	701	inoblastoma-like 1(p107) (Rbl1); transcriptional cell cycle repression; tumor pressor gene; binds to myc gene	hest in liver and heart embryo, lower in adult liver, CNS, iferating cells, heart, lung, kidney, intestine
0.117	0.000	5603	aete-scute complex homolog-like sophila) (Ascl1); helix-loop-helix protein scriptional factor; controls a basic ration in development of neuronal enitors in distinct neural lineages	eloping CNS and peripheral nervous systems, in adult n only
0.124	0.007	4120	ivin receptor IIB (Acvr2b); receptor for vins, which play an important part in odern induction	ryo, testis
0.374	0.006	546	-ribosylation-like 4 (Arl4); ADP- sylation factor like protein 4; involved in ation of transport vesicles; expressed in erentiating cells	pocytes, ubiquitous

0.856	0.027	478	binding protein 1 (Aebp1); transcriptional repressor with carboxypeptidase activity; no expression during adipocyte differentiation or oblast calcification	adipose tissue
0.221	0.027	1705	alkaline phosphatase 3, intestinal, not mineralizing (Akp3); intestinal alkaline phosphatase (IAP); a membrane-bound alloenzyme catalyzing cleavage of organic phosphate nonspecifically from a variety of phosphate esters.	intestine, kidney
0.592	0.009	361 and 1891	amylase 2, pancreatic (Amy2); J00361; alpha-amylase-like gene; glycogen storage and mobilization	creases, liver and many others
0.125	0.001	676	amyloid beta (A4) precursor protein-binding, family A, member 2 (Apba2); X11 protein; X11 protein binds amyloid precursor protein; receptor trafficking; may regulate the processing of amyloid precursor protein to the amyloid beta peptide	neurons
0.071	0.006	216	lipoprotein CII (Apoc2); required for hydrolysis of triglycerides by lipoprotein lipase	liver, adult liver, intestine and peritoneal macrophages
0.371	0.006	573	nerve derived neurotrophic factor (Bdnf); regulates development and maintenance of the nervous system	brain, highest in hippocampus and cerebral cortex
0.062	0.004	740	casein delta (Csnd); epsilon-casein (milk)	mammary glands
0.324	0.016	526	8 antigen (Cd48); BCM-1; Blast-1; mediates cell adhesion	surface of leukocytes
0.796	0.024	562	division cycle 25 homolog C (S. pombe) (Cdc25c); encodes nine/tyrosine phosphatases that activate cyclin-dependent kinases; control of mitosis between phases of cell division	spleen and thymus

0.101	0.039	715	ular retinoic acid binding protein 1 (bp1); intracellular lipid binding protein a high affinity for retinoic acid	ely expressed during development also in thymus
0.051	0.006	690	omobox homolog 1 (Drosophila HP1 beta) x1); Homologous to Drosophila HP1 gene; if's chromatin, rendering heritable changes gene expression; activates or silences es	quitous during development
0.541	0.002	032	lin B2 (Ccnb2); regulator of transitions een phases of cell division	hest in pachytene spermatocytes, also in early ryogenesis
0.343	0.002	771	ochrome c, testis (Cyc1); maintains tinous spermatogenesis	itis
0.110	0.016	859	D (aspartate-glutamate-alanine-aspartate) polypeptide 4 (Ddx4); DNA helicase; ortant role in determination events of cells	ryonic gonads and testicular germ cells
0.059	0.034	3226	ensin related sequence cryptdin peptide eth cells) (Defcr-rs1); CRS1C; microbial peptide	eth cells of the small intestine; smooth muscle
0.044	0.031	903	a-like 1 homolog (Drosophila) (Dl1); cell-communication regulating the rmination of various cell fates during elopment	ryo, not in adult liver
0.167	0.038	986	mocollin 1 (Dsc1); a "skin-type" mosomal cadherin; formation of tinized epithelial structure during mouse elopment; cell to cell adhesion	ryo and skin
0.475	0.002	963	hanous homolog 1 (Drosophila) (Diap1); in regulation of cell morphology, adhesion cytokinesis; Rho regulates actin merization by targeting profilin via the hanous homolog 1 beneath specific ma membranes	oblasts (ubiquitous)
0.174	0.027	925	transcription factor 5 (E2f5); M.musculus mRNA for E2F-5 protein.	
0.899	0.000	328	-like module containing, mucin-like, hormone receptor-like sequence 1 (Emr1); M.musculus mRNA for O.	
0.177	0.010	2930	hropoietin (Epo); M12930 Mouse erythropoietin gene, complete cds	

0.143	0.023	325	ogenital dysplasia homolog (Fgd1); U22325 Mus musculus faciogenital dysplasia (Fgd1) mRNA, plete cds
0.993	0.047	1737	specific gene 27 (Fsp27); M61737 M.musculus adipocyte-specific mRNA, partial cds
0.062	0.046	535	oblast growth factor 9 (Fgf9); U33535 Mus musculus fibroblast growth factor 9 (FGF-9) mRNA, plete cds
0.993	0.003	853	lin 1 (Fbln1); M.musculus (isolate Mk24) mRNA for the 3' end of MB-90/fibulin C form.
0.358	0.006	854	lin 1 (Fbln1); M.musculus (isolate Mk31) mRNA for MB-90/fibulin D form.
0.150	0.002	099	junction membrane channel protein beta 3 (Gjb3); connexin31.
0.341	0.000	953	olin (Gsn); J04953 Mouse gelsolin gene, complete cds
0.956	0.001	265	osaminyl (N-acetyl) transferase 1, core 2 (Gcnt1); U19265 Mus musculus core2-GlcNAc-transferase -GnT) mRNA, complete cds
0.374	0.008	996	th factor receptor bound protein 10 (Grb10); U18996 Mus musculus growth factor receptor-binding ein (Grb10) gene, complete cds
0.145	0.041	0422	one 4 protein (Hist4); J00422 Mouse histone H4 gene, complete cds
0.724	0.000	071	eo box C5 (Hoxc5); U28071 Mus musculus homeobox protein (Hoxc-5) gene, complete cds
0.207	0.037	519	roxysteroid dehydrogenase-5, delta<5>-3-beta (Hsd3b5); Mus musculus 3-ketosteroid reductase D3b5) mRNA, complete cds
0.116	0.003	973	feron alpha family, gene 4 (Ifna4); X01973 Mouse gene for interferon alpha 4 (Mu IFN-alpha 4)
0.095	0.007	599	feron gamma receptor 2 (Ifngr2); U69599 Mus musculus interferon gamma receptor second chain r2) gene
0.008	0.015	542	leukin 6 (Il6);
0.566	0.008	359	359 mouse alpha-amylase-2 gene
0.086	0.009	761	oncogene (Jun); Mouse mRNA for protein homologous to human c-JUN.
0.785	0.046	08574	voltage-gated channel, subfamily S, 2 (Kcns2)Mus musculus potassium channel alpha subunit 9.2) mRNA, complete cds.
0.128	0.018	193	tin complex 1, acidic, gene 10 (Krt1-10); L00193 Mouse epidermal keratin type I intermediate ent gene
0.053	0.026	313	tin complex 1, acidic, gene 15 (Krt1-15); cytoskeletal structural protein D16313 Mouse cytokeratin gene, complete cds
0.071	0.002	889	r cell lectin-like receptor, subfamily A, member 8 (Kira8); U12889 Mus musculus Ly49H mRNA, plete cds
0.763	0.002	4398	rin (Lor); M34398 Mouse loricrin mRNA, complete cds
0.088	0.016	503	phoid enhancer binding factor 1 (Lef1); D16503 Mouse mRNA for LEF-1S, complete cds
0.079	0.001	3099	usculus epidymal sperm gene.
0.701	0.026	3121	usculus mRNA for alpha tectorin.
0.016	0.019	3404	usculus mRNA for axonemal dynein heavy chain (partial, ID mdhc8).
0.145	0.003	3397	usculus mRNA for cytoplasmic dynein heavy chain (partial, ID mdhc11).

0.591	0.000	3151	usculus mRNA for neural cell adhesion molecule.
0.119	0.047	3209	usculus mRNA for Nkx2-3 gene.
0.225	0.040	3083	usculus PR264 gene.
0.208	0.034	595	gen activated protein kinase kinase kinase 2 (Map4k2); U50595 Mus musculus Rab8- racting protein mRNA, complete cds
0.139	0.000	3431	se DNA for neurotrophic factor, exon 3 and complete cds.
0.044	0.039	3429	se DNA for vav-T, partial cds.
0.392	0.032	997	se mRNA for cytotoxic T-cell membrane glycoprotein Ly-3 3'flank.
0.153	0.028	1015	se NLRR-2 mRNA for leucine-rich-repeat protein, partial cds.
0.427	0.015	210	musculus (Notch2) mRNA, complete
0.000	0.034	2373	musculus ACF7 neural isoform 1 (mACF7) mRNA, partial cds.
0.066	0.000	3257	musculus cea12 gene.
0.087	0.028	3255	musculus cea9 gene.
0.302	0.034	1200	musculus complement receptor (CRY) mRNA, partial cds (spleen-specific).
0.170	0.000	1528	musculus CRE-BP1 transcription factor, novel spliced form, mRNA, partial cds.
0.189	0.043	2694	musculus glucose-6-phosphate dehydrogenase (G6PD) gene, nuclear gene encoding mitochondrial ein, exon 6 and partial cds.
0.374	0.000	1692	musculus implantin mRNA, partial cds.
0.142	0.018	2692	musculus laminin alpha 3B chain (Lama3B) mRNA, partial cds.
0.346	0.005	2477	musculus mena protein (Mena) mRNA, complete cds.
0.155	0.000	1218	musculus microtubule-associated protein 4 (MAP4) mRNA, partial cds.
0.075	0.001	1544	musculus P-glycoprotein (mdr2) gene, partial cds.
0.084	0.040	2235	musculus polyreactive autoantibody, immunoglobulin IgM heavy chain mRNA, partial cds.
0.074	0.001	1683	musculus potassium channel mKv3.2 mRNA, partial cds.
0.043	0.019	1621	musculus putative protein kinase MRK2 mRNA, partial cds.
0.110	0.026	1556	musculus rearranged T cell receptor (TCRV-alpha-22.1) mRNA, variable region, partial cds.
0.191	0.026	2586	musculus sodium channel 2 (mBNaC2) mRNA, partial cds.
0.104	0.033	2280	musculus T cell receptor V alpha mRNA, partial cds.
0.459	0.003	1439	musculus trp-related protein 2 mRNA, partial cds.
0.061	0.002	1441	musculus trp-related protein 5 mRNA, partial cds.
0.054	0.004	0474	istoylated alanine rich protein kinase C substrate (Mac3); M60474 Mouse myristoylated alanine-rich inase substrate (
			RCKS) mRNA, complete cds
0.378	0.017	360	plastic progression 1 (Npn1); M.musculus (Balb/C) P/L01 mRNA.
0.153	0.000	919	roblastoma myc-related oncogene 1 (Nmyc1); Mouse N-myc gene.

0.827	0.049	819	ropeptide Y receptor Y1 (Npy1r); D63819 Mouse mRNA for neuropeptide Y-Y1 receptor, complete
0.186	0.000	0514	al (Nodal); X70514 M. musculus nodal gene, a TGF-beta-like gene
0.133	0.046	163	gin (Nog);
0.238	0.029	033	lear protein 220 (Np220); Mouse mRNA for nuclear protein, NP220, complete cds
0.062	0.000	804	rnally expressed gene 3 (Peg3); U48804 Mus musculus Zn-finger protein Pw1 gene, complete cds
0.348	0.030	687	nylethanolamine-N-methyltransferase (Pnmt); L12687 Mouse phenylethanolamine N-hyltransferase gene, complete cds
0.307	0.005	279	sphatidylinositol 3-kinase, catalytic, alpha polypeptide (Pik3ca); U03279 Mus musculus Balb/c sphatidylinositol 3-kinase 110 kDa subunit mRNA, complete cds
0.233	0.046	277	sphatidylinositol 3-kinase VII (platelet-activating factor acetylhydrolase, plasma) (Pla2g7); U34277 Mus spholipase A2 group VII (platelet-activating factor acetylhydrolase mRNA, complete cds
0.408	0.000	305	culus PAF acetylhydrolase mRNA, member 1 (Kcna1); Mouse MBK1 mRNA for ssium voltage gated channel, shaker related subfamily, member 1 (Kcna1); Mouse MBK1 mRNA for se brain potassium channel protein-1.
0.958	0.038	789	iferation-associated protein 1 (Pifap); M.musculus mRNA for p38-2G4.
0.063	0.000	594	iferin related protein (Pifr); Mouse mRNA for proliferin-related protein (PRP).
0.146	0.009	532	ein kinase C, beta (Pkcb); Mouse mRNA for protein kinase C beta-II.
0.109	0.009	242	ein kinase C, eta (Pkch); D90242 Mouse mRNA for nPKC-eta
0.188	0.047	577	ein kinase C, lamda (Pkcl); Mouse mRNA for protein kinase C lambda
0.196	0.049	935	ein kinase, cAMP dependent regulatory, type II alpha (Prkar2a); J02935 Mouse cAMP-dependent ein kinase type II regulatory subunit mRNA, 3' end
0.542	0.011	720	ein that interacts with C kinase 1 (Pick1); M.musculus mRNA for perinuclear binding protein.
0.374	0.013	768	eoglycan 2, bone marrow (Prg2); L46768 Mus musculus major basic protein (MBP-1) gene, complete
0.256	0.013	133	eoglycan, secretory granule (Prg); Mouse mRNA for mastocytoma proteoglycan core protein, lycin.
0.904	0.022	239	5B, member RAS oncogene family (Rab5b); X84239 M.musculus mRNA for rab5b protein
0.010	0.027	247	-related C3 botulinum substrate 2 (Rac2); M.musculus EN-7 mRNA.
0.115	0.034	711	ication factor C, 140 kDa (Recc1); M.musculus mRNA for replication factor C, large subunit.
0.463	0.023	642	finger protein (C3HC4 type) 19 (Rnf19)X71642 M.musculus GEG-154 mRNA
0.694	0.021	5732	inal vesicle protein 2 (Svp2); Mouse seminal vesicle secretory protein IV (SVS IV) mRNA, 3' end
0.714	0.032	7790	m amyloid A pseudogene (Saa-ps); M17790 Mouse 'SAA4 gene encoding serum amyloid A, exons 3 4
0.009	0.021	580	en in absentia 1B (Siah1b); M.musculus siah-1B protein mRNA.
0.103	0.021	687	ium channel, voltage-gated, type I, beta polypeptide: (Scn1b); L48687 Mus musculus voltage-ndent Na + channel beta-1 subunit gene, exons 4-6
0.328	0.002	268	te carrier family 35 (CMP-sialic acid transporter), member 1 (Slc35a1); M.musculus mRNA for CMP-ic acid transporter.

known genes: 2-fold up in old CR vs. old Control and unchanged in young CR vs. young Control

	R	1	2	3	7	8	9	st	ngCR	ngCR	ngCR	ngCont	ngCont	st	notype	ue distribution
	R	1	2	3	7	8	9	st	ngCR	ngCR	ngCR	ngCont	ngCont	st	notype	ue distribution
602	8.75	11.48	3.04	0.00	0.00	0.00	0.00	0.003	0.00	0.00	29.61	0.00	0.00	0.00	.374	e morphogenetic oblastic cells; tein 2 (Bmp2); is or types of mponent of a -hematopoietic e-derived extract s (these cells ical to initiation of uded ation of cartilage oblasts, its conversion tinocytes, bone; is ocytes, kidney cturally related helial cells, and ransforming or cells of with facto-beta s, e, muscle, vins, and , liver, kidney, bins. BMP ach, colon, aling is essential state, and development of ronal tissue) letogenic and rogenic cranial ral crest.
3463	2.96	1.91	0.92	0.00	0.00	0.00	0.00	0.031	2.38	1.43	1.49	1.08	0.62	0.00	.052	YDROXYACYLSPHINGOSINE 1-A-GALACTOSYLTRANSFERASE CURSOR (EC 2.4.1.45) (UDP-LACTOSE-CERAMIDE LACTOSYLTRANSFERASE) RAMIDE UDP-LACTOSYLTRANSFERASE) REBROSIDE SYNTH
2773	1.04	0.96	1.92	0.16	0.00	0.00	0.00	0.016	1.99	2.96	1.05	0.00	0.00	1.77	.155	HRIN-A3 (EPH-RELATED EPTOR TYROSINE KINASE AND 3) (LERK-3) (EHK1 LIGAND) K1-L) (FRAGMENT).

019	1.31	0.96	1.29	0.00	0.56	0.58	0.022	1.04	0.87	1.44	1.13	0.72	1.25 .726	igin (Bsg); 019 Mouse gene basigin precursor, igin signal ursor
991	0.78	1.33	1.43	0.34	0.58	0.37	0.025	1.12	1.84	1.91	0.00	0.88	1.83 .289	itonin (Calc)
343	5.03	16.01	1.89	0.00	0.00	0.00	0.001	0.00	0.00	27.69	0.00	0.00	0.00 .374	ium channel beta bunit (Cacnb2); tage-sensitive ium channels are ely expressed plexes which e both trogenic and al transduction ctions.
966	2.24	2.14	1.72	0.83	1.05	0.52	0.005	0.80	1.47	0.95	0.88	0.80	2.05 .725	onyl reductase 1 r1);a cytosolic ber of the aldo- reductase group nzymes. uitous enzyme abolize a variety ompounds taining carbonyl ups.

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255	1.25	1.99	2.59	0.00	0.59	0.00	0.016	1.44	0.75	1.26	0.00	1.27	0.00	.197	Kruppel family ber GLI3 musculus mRNA Gli3 protein.
498	1.47	1.76	1.46	0.70	0.87	0.66	0.002	0.74	1.04	0.96	0.91	1.30	1.53	.178	amate cysteine se (gamma- amylcysteine thetase), catalytic lc);
498	5.92	22.45	4.96	0.00	0.00	0.00	0.039	5.05	1.71	28.66	0.00	0.00	0.00	.236	amate receptor, tropic, AMPA2 ha 2) (Gria2);
754	9.29	15.43	1.98	0.00	0.00	0.00	0.002	7.98	18.64	0.00	0.00	0.00	0.00	.116	t shock factor 2 f2)M.musculus NA for heat shock scripton factor 2.
0365	2.12	2.48	2.79	0.00	1.29	0.00	0.013	2.69	0.91	0.37	1.09	0.00	0.00	.291	tion plakoglobin (Jup); one of the teins of desmosomal membrane horage site plaques of the helium, and is also a component of ues of the adherins junction
239	5.76	13.54	7.04	0.00	0.00	0.00	0.022	2.55	0.00	26.67	0.00	0.00	0.00	.316	uscuscul mRNA goosecoid eobox.
778	1.17	17.10	8.21	0.00	0.00	13.02	0.032	9.71	2.14	0.00	0.00	0.00	0.00	.251	usculus H2B e.
889	0.94	1.46	1.95	0.65	0.00	0.55	0.041	1.42	1.73	0.91	0.70	2.19	1.06	.950	usculus mRNA wnt-8D protein.
796	6.71	6.58	0.91	0.00	0.00	0.00	0.046	3.72	13.92	38.64	0.00	0.00	0.00	.056	usculus mRNA ologous to S. visiae RAD54.
942	4.93	4.23	1.66	0.55	0.00	1.26	0.047	4.85	0.74	4.66	0.00	0.68	0.44	.088	usculus mRNA nhancer-trap- s 1.
060	3.39	1.14	1.65	0.18	0.00	0.00	0.043	0.86	2.53	2.91	8.19	0.00	0.00	.834	usculus myf-6 e.

2974	2.34	1.55	1.44	0.00	0.00	0.00	0.003	1.35	1.03	2.14	0.97	0.69	0.00	.096	usculus SOX1 e.)PIR:S10950 -determining tein - mouse gment)
3453	6.48	30.32	7.19	0.00	0.00	0.00	0.009	9.94	4.23	2.36	0.00	0.00	0.00	.273	3453 Mouse somal protein ' (rpL32') gene, plete cds
885	1.34	1.23	2.44	0.20	0.84	0.00	0.046	0.00	0.00	5.53	2.69	1.16	0.00	.794	toctytoma N-deacetylase/N- otransferase (Mndns); usculus mRNA for glucosaminyl eacetylase / N-sulfotransferase.
461	2.63	1.67	1.27	0.40	0.00	0.00	0.015	1.26	1.84	0.81	0.00	1.19	0.00	.144	rine Hox2.2 NA for a eobox protein.
1617	1.41	1.14	1.53	0.86	0.25	0.57	0.019	1.18	1.72	1.38	0.76	0.71	0.73	.012	s musculus 5E6 6/Ly-49C) mRNA, plete cds.
2456	1.22	9.34	6.07	0.00	0.00	0.00	0.036	3.70	0.00	0.00	4.26	0.00	0.00	.420	s musculus in-2 mRNA, ial cds.
2752	1.25	1.27	0.96	0.71	0.28	0.75	0.032	1.26	1.14	1.18	0.81	0.55	1.04	.053	s musculus tocyst unknown tein mRNA, partial
3262	0.84	1.16	1.18	0.65	0.00	0.19	0.025	1.32	1.29	1.36	1.27	0.04	0.73	.143	s musculus cea17 e.
2465	1.51	1.15	0.99	0.48	0.00	0.66	0.029	1.82	1.34	1.01	0.68	0.79	2.48	.913	s musculus erbB2 NA, partial cds.
737	1.13	0.87	1.16	0.00	0.76	0.00	0.041	1.26	1.33	0.00	1.41	1.27	0.80	.557	s musculus ne/threonine- tein kinase 4m (PRP4m) NA, complete cds

429	4.85	13.23	5.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.374	21 homolog (S. pombe) d21); D49429 Mouse P-29 mRNA for PW29, plete cds
071	1.10	1.20	1.12	0.73	0.26	0.70	0.021	0.92	0.83	1.45	0.80	1.08	1.10	750 -related orphan ptor gamma rc);
506	2.15	1.49	1.34	0.96	0.78	0.12	0.044	0.34	1.51	0.07	0.20	1.61	1.04	634 binding motif tein 4 (Rbm4);
921	2.76	2.75	2.49	0.31	0.90	0.00	0.001	1.10	0.00	2.28	0.00	1.38	0.05	461 0 calcium-binding protein A13 OOa13); M.musculus mRNA for 0 calcium-binding protein A13.
262	3.53	2.20	2.52	0.33	0.22	0.17	0.003	1.45	0.55	2.37	0.26	1.70	0.00	341 solute carrier family 1, member 1 (Slc1a6); a Purkinje-cell specific neuronal glutamate transporter
542	1.58	1.23	1.42	0.85	0.00	0.00	0.020	0.57	1.61	1.68	0.00	0.71	1.15	247 ocerebellar ataxia 1 homolog an) (Sca1) M.musculus mRNA ataxin-1.
184	1.22	8.76	8.97	0.00	0.00	0.00	0.013	3.50	0.00	2.35	2.67	0.00	0.00	360 ell expressing clone j6 (Tj6); usculus J6B7 mRNA for T cell duced protein.
796	1.68	8.76	8.91	0.00	0.00	0.00	0.000	2.27	24.48	0.00	0.00	0.00	0.00	117 is specific X- ed gene (Tsx);
861	2.82	1.65	2.44	0.82	0.81	0.88	0.013	1.02	1.00	0.65	0.63	1.00	1.46	626 1 cytotoxic ule-associated -binding protein- 1 (Tial1); ptosis
4429	1.32	1.12	1.18	0.43	0.80	0.00	0.029	1.20	1.03	0.97	0.40	0.46	2.07	872 scriptional mediary factor lpha (Tif1a);
167	0.77	1.50	1.38	0.20	0.14	0.64	0.032	1.23	1.26	1.51	1.60	0.01	0.00	213 sient receptor tein 1 (Trp1);
697	2.55	3.62	3.28	0.00	0.00	0.00	0.001	2.71	3.07	0.00	0.00	0.00	2.33	407 oil factor 2 (spasmolytic protein Tff2); M.musculus spasmolytic peptide (SP) mRNA.

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960	1.87	1.22	0.84	0.00	0.00	0.14	0.015	1.03	0.00	1.18	3.37	3.78	0.97	.107	sine kinase ptor. 1 (Tie1); usculus mRNA TIE receptor sine kinase. 297 Mus culus chrome B561 yt) mRNA, plete cds 399 Mus culus Cdk- bitor p57KIP2 2) mRNA, plete cds 788 Human ative cytochrome c- e synthetase NA, complete cds 818 Mus culus tuberin C2) mRNA, plete cds 925 Mus culus scription factor mRNA, complete
297	0.99	1.46	1.35	0.00	0.00	0.00	0.0001	1.26	1.32	1.01	0.59	0.14	1.06	.100	085 Mus culus thiazide- sitive Na-Cl ransporter mRNA, plete cds 673 Mus musculus histone (A)-613, histone H2a(B)-613, and one H2b-613 (H2b) genes, plete cds
399	6.64	22.65	5.57	0.00	0.00	0.00	0.0001	4.45	42.28	9.23	0.00	0.00	0.00	.099	
788	1.60	1.19	2.04	0.00	0.00	0.00	0.0003	1.25	0.92	1.93	0.35	0.00	1.08	.111	
818	1.30	1.21	0.93	0.79	0.09	0.52	0.043	1.07	0.68	0.51	1.45	2.13	1.88	.014	
925	1.35	1.33	0.87	0.43	0.50	0.50	0.012	0.13	1.13	1.49	1.27	1.83	0.00	.871	
085	1.43	1.51	0.76	0.00	0.00	0.47	0.020	1.40	1.24	1.56	0.00	0.00	8.39	.645	
673	2.43	25.66	2.46	2.34	0.00	0.00	0.028	6.97	0.00	0.00	0.00	0.00	0.00	215.85	

1677	3.66	3.39	4.44	0.00	0.00	0.00	0.000	2.77	2.79	0.93	0.00	0.00	1.07	.065	ILORIDE-SENSITIVE SODIUM NNEL ALPHA-SUBUNIT (LUNG CHANNEL ALPHA SUBUNIT) PHA ENAC) (NONVOLTAGE- TED SODIUM CHANNEL 1 ALPHA UNIT) (SCNEA) (ALPHA NACH) AGMENT).
2211	1.51	1.55	1.09	0.84	0.47	0.24	0.019	1.42	0.91	1.32	0.29	0.45	1.09	.104	s musculus ant formin (Fmn) e, partial cds.
2229	1.20	1.67	1.04	0.00	0.00	0.00	0.002	1.23	1.68	1.36	0.55	0.96	0.94	.031	s musculus t10b mRNA, plete cds.
2444	2.44	1.02	0.98	0.00	0.00	0.00	0.037	1.41	1.71	2.08	0.00	1.14	0.94	.060	s musculus Sox4 x4) mRNA, partial
2446	9.81	28.01	8.98	0.00	0.00	0.00	0.000	9.16	15.36	0.29	0.00	0.00	0.00	.182	s musculus Sox12 x12) mRNA, ial cds.
2570	1.20	1.21	1.81	0.60	0.00	0.40	0.016	0.80	2.67	3.46	0.00	0.23	1.22	.105	s musculus Mad olog Smad5 NA, complete
2673	1.24	1.58	1.28	0.35	0.93	0.00	0.033	1.74	0.41	0.70	1.76	1.07	0.26	.900	use hyaluronan thase 3 mRNA, plete cds.
2998	0.93	1.07	1.36	0.07	0.00	0.00	0.001	1.19	1.08	1.34	0.51	0.01	1.21	.153	usculus mRNA dystrobrein ne m32).
3005	1.98	1.19	0.81	0.00	0.00	0.00	0.018	0.00	2.97	1.35	3.07	5.28	0.00	.487	usculus mRNA phospholipase C ma 1.
3019	0.61	1.69	1.47	0.00	0.39	0.00	0.033	1.39	1.55	1.93	0.00	1.43	0.00	.086	usculus skeletal cle ryanodine ptor gene.
3122	1.10	1.77	1.18	0.62	0.51	0.52	0.021	0.84	1.19	1.52	1.33	0.74	0.90	.515	usculus mRNA beta tectorin.

3226	1.13	1.26	1.06	0.59	0.30	0.64	0.006	1.02	0.98	1.05	0.47	0.79	1.15	.331	usculus htlf e, exon.
3241	1.07	1.17	0.98	0.51	0.45	0.39	0.001	1.69	1.02	1.23	0.52	0.63	1.60	.370	OPAIN PRECURSOR (EC 3.4.22.-) STEINE PROTEASE CPP32) MA PROTEIN) (CASPASE-3) E).
3410	1.13	1.60	1.69	0.36	0.58	0.00	0.009	1.05	1.19	1.25	0.04	0.95	0.46	.065	usculus mRNA semaphorin Hv 88 bp).
3528	1.25	1.34	1.14	0.43	0.17	0.18	0.001	1.00	1.11	1.00	0.29	0.00	1.19	.207	s musculus A- protein (A-myb) e, partial cds.
293	8.72	10.87	2.41	0.00	0.00	0.00	0.001	0.00	2.18	0.00	8.26	2.35	0.00	.335	use skeletal cle sphorylase se, gamma unit mRNA, plete cds
298	1.25	1.49	1.34	0.00	0.76	0.89	0.046	1.64	1.08	1.06	0.94	0.80	0.36	.095	298 Mouse rine otransferrin NA
060	6.51	7.40	5.77	2.15	0.00	0.00	0.002	3.72	7.47	0.00	0.00	0.00	0.00	.159	060 Mouse somal protein, e 3A coding for
785	1.75	0.96	1.61	0.73	0.26	0.00	0.027	2.30	1.04	1.75	0.65	1.40	0.00	.138	use mRNA ced by PDGF h some homology -fos.
928	2.01	3.91	3.04	0.00	1.45	0.00	0.027	5.18	0.00	0.00	1.79	0.55	0.23	.654	s musculus erentiation igen (CD22) NA, complete
472	1.38	1.81	1.41	0.00	0.52	0.00	0.004	1.84	0.70	1.23	1.50	0.35	0.77	.458	472 Mouse Bax a mRNA, plete cds

662	1.03	1.38	0.83	0.00	0.21	0.35	0.009	1.49	1.29	1.35	1.41	0.67	0.97 .181s musculus
													ofetal antigen
													NA, partial cds
982	2.02	1.71	1.86	0.42	0.21	0.28	0.000	2.28	2.53	0.98	0.00	1.02	0.00 .054 982 Mus
													culus Balb/c
													roendothelin-1
													e, promoter
													on
210	5.68	14.95	9.70	0.00	0.00	0.00	0.012	6.61	4.29	14.29	0.00	0.00	0.00 .080 210 Mus
													culus
													oelastin mRNA,
													plete cds
932	1.42	1.13	1.28	0.86	0.16	0.48	0.024	1.40	1.30	0.87	0.00	0.80	1.32 .313 932 Mus musculus follicle
													ulating hormone beta subunit
													H-beta) gene, complete cds
443	1.24	0.89	1.26	0.00	0.07	0.03	0.001	1.11	1.51	1.21	0.13	0.70	1.82 .480 443 Mus
													culus proto-
													ogene protein c-
													(c-ros) mRNA,
													plete cds
252	0.92	1.07	1.19	0.00	0.20	0.32	0.002	1.19	1.05	1.34	0.95	1.09	0.73 .114 252 Mus
													culus
													abotropic
													amate receptor 8
													luR8) mRNA,
													plete cds
513	1.01	1.45	1.29	0.68	0.18	0.72	0.029	1.09	1.29	1.12	0.00	0.99	0.12 .067 513 Mus
													culus KRAB-zinc
													er protein 79
													79) mRNA,
													ial cds
005	3.41	10.25	4.71	0.00	0.00	0.00	0.043	0.00	7.73	9.70	7.06	0.00	0.00 .412s musculus tbc1
													NA, complete cds
245	0.89	1.28	1.19	0.00	0.00	0.00	0.001	1.21	1.16	1.11	0.00	1.24	0.00 .145 245 Mus
													culus fos-related
													igen-1 (Fra-1)
													NA, complete cds

353	1.01	1.29	1.30	0.00	0.49	0.00	0.005	1.07	0.99	1.36	0.60	1.07	0.12 .105	353 Mus musculus protein sphatase 2A B'alpha3 regulatory unit mRNA, partial cds
189	1.11	0.90	0.86	0.20	0.00	0.65	0.030	1.40	1.23	1.29	1.10	0.83	1.74 .777	189 Mus musculus pancreatic peptide/neuropeptide Y/peptide receptor gene, complete cds
650	1.29	1.15	1.17	0.17	0.64	0.00	0.009	1.28	1.30	1.17	0.75	0.85	0.35 .020	650 Mus musculus neurexophilin xph-2) gene, large exon and 3' of the intron, and partial cds
513	0.81	1.09	1.05	0.51	0.36	0.59	0.010	1.02	1.00	1.00	1.23	0.99	1.35 .150	513 Mus musculus Rho- ociated, coiled-coil forming protein se p160 ROCK-2 mRNA, complete
418	0.96	1.45	1.72	0.00	0.78	0.44	0.037	2.23	1.04	1.13	1.04	0.51	0.00 .123	418 Mus culus Netrin-1 rin-1) mRNA, plete cds
137	1.82	1.59	1.58	0.00	0.72	0.95	0.020	1.73	1.03	1.35	0.36	0.97	0.65 .057	137 Mus culus T2- herin mRNA, ial cds
208	1.92	19.41	5.95	0.00	0.00	0.00	0.007	8.28	13.48	38.84	0.00	0.00	0.00 .099	208 Mus culus neurogenin gn3) gene, plete cds
700	5.11	3.18	3.26	0.00	0.00	0.00	0.004	5.33	1.30	4.75	0.70	0.00	0.36 .054	s musculus serine teinase inhibitor 6 l6) mRNA, plete cds.
724	8.41	5.29	5.43	0.00	2.24	0.00	0.011	1.15	1.53	0.00	0.85	0.00	0.00 .324	s musculus ative sphoinositide 5- sphatase type II NA, complete

755	2.04	2.40	1.68	0.82	1.17	0.10	0.023	0.83	1.63	1.18	0.00	0.82	0.71 .110	senger RNA ment for mouse rferon beta (type oding for the c- inal part.
479	1.64	1.70	1.36	0.32	0.08	1.17	0.039	1.03	0.58	1.19	0.67	0.97	0.00 .317	use mRNA ment for serum loid A (SAA) 3 tein.
123	1.69	1.82	1.59	0.43	0.37	0.99	0.006	1.01	1.70	2.45	0.04	0.99	0.56 .075	use mRNA for inal xynucleotidyltran ase (TdT).
260	1.15	1.82	2.55	0.00	0.00	0.00	0.011	3.64	1.63	0.95	1.05	0.00	0.21 .130	use Y mosome RNA script expressed estis (pYMT2/B).
640	1.17	27.06	1.14	0.00	0.00	0.00	0.000	2.21	3.04	6.96	0.00	0.00	0.00 .050	640 Mouse NF- ene for middle- ecular-mass rofilament protein
115	1.83	1.63	1.23	0.00	0.00	0.17	0.001	1.15	1.02	0.98	0.15	0.24	1.02 .105	use mRNA for E- herin (= morulin, = L- , = cell-CAM /80, = Arc-1).
368	3.83	11.36	2.49	0.00	0.00	0.00	0.016	0.00	0.05	16.10	27.29	1.95	0.00 .693	rine mRNA for c- proto-oncogene.
540	1.07	1.23	1.56	0.34	0.00	0.47	0.007	1.08	1.38	1.02	0.38	0.98	0.65 .078	540 Mouse c-abl e exon 1 of type RNA
538	7.03	5.05	0.26	0.00	0.00	0.00	0.036	0.00	1.26	14.07	26.77	0.00	0.74 .702	rine mRNA for -1.4 protein.
664	1.47	2.17	1.59	0.13	0.76	0.90	0.023	1.13	1.20	0.25	0.00	0.18	1.10 .400	use mRNA for N- protein (exons 1 - art.).
926	1.00	1.00	1.56	0.00	0.00	0.00	0.003	1.22	1.11	1.17	1.17	0.00	0.00 .117	use mRNA for eticulin.

972	1.63	2.07	1.66	0.55	0.66	0.85	0.003	1.99	1.04	1.95	0.79	0.00	0.96	.067	use mRNA for a-adaptin (C).
830	1.42	1.63	1.21	0.56	0.00	0.00	0.005	1.12	1.07	0.87	0.93	0.23	1.82	.956	rine mRNA for roendocrine tein 7B2.
510	4.28	8.23	5.27	0.00	2.36	0.00	0.023	6.86	5.28	0.00	0.00	0.00	0.00	.123	use mRNA for 3.3 PRI script.
683	4.96	35.96	6.00	0.00	0.00	0.00	0.001	1.44	32.38	0.00	0.00	0.00	0.00	.136	usculus T NA.
991	2.51	3.70	4.67	0.00	0.00	0.00	0.004	2.85	9.53	3.06	0.00	0.00	0.00	.079	991 Mouse NA for homologue he rat T cell erentiation marker
424	2.42	0.95	2.24	0.00	0.00	0.00	0.016	1.05	2.97	2.58	0.00	0.35	1.76	.134	424 Mouse NA for gamma ptin
315	1.56	5.39	4.68	0.00	0.33	0.44	0.038	5.99	1.85	1.68	0.00	0.00	0.00	.088	usculus mRNA CAAT-box DNA ing protein unit A (NF-YA) tial).
781	0.99	1.53	1.53	0.06	0.49	0.78	0.030	1.10	1.36	1.13	0.72	1.01	0.72	.040	781 M.musculus 2 gene
044	1.26	1.03	1.66	0.71	0.40	0.27	0.019	1.10	1.23	1.59	0.97	0.47	0.79	.053	044 M.musculus NA for protein C
349	2.20	1.22	2.82	0.00	0.78	0.00	0.027	6.12	2.09	1.98	0.00	0.00	0.00	.067	349 M.musculus NA for transferrin ptor
960	1.01	56.29	4.13	0.00	0.00	0.00	0.000	6.85	17.60	0.00	0.00	0.00	0.00	.191	usculus mRNA ribosomal protein
876	0.96	1.54	0.93	0.00	0.00	0.17	0.006	2.15	1.64	1.04	3.04	0.00	1.10	.823	876 Murine 2 mRNA for 2 protein

940	1.01	0.88	0.80	0.43	0.24	0.19	0.003	1.03	1.55	1.66	0.99	1.15	1.06. 160 use mRNA for a wth.factor-
285	2.49	1.96	1.92	0.00	0.00	0.00	0.000	1.64	2.00	0.82	0.00	1.18	cible immediate y gene (3CH134). 285 M.musculus for HC1 locus
449	1.44	1.75	1.43	0.00	0.00	0.00	0.000	1.58	1.36	0.64	0.00	0.00	2.12. 558 449 M.musculus NA for calcyclin
783	4.50	3.48	4.48	0.47	0.00	1.53	0.003	3.31	3.70	0.00	0.00	0.00	0.00. 117 usculus VCAM-1 NA.
061	1.34	1.51	1.45	0.74	0.41	0.56	0.001	1.55	1.08	1.02	0.98	0.29	0.65. 093 usculus HCNGP NA.
620	4.60	22.94	3.86	0.00	0.00	0.00	0.000	6.71	34.28	0.00	0.00	0.00	0.00. 161 usculus mRNA inhibin beta-B unit.
018	1.41	1.13	1.17	0.29	0.53	0.87	0.024	1.27	1.39	0.72	0.85	0.75	2.28. 775 018 M.musculus NA for Id4 helix- -helix protein
295	0.99	1.24	1.01	0.00	0.24	0.65	0.079	1.17	0.69	1.28	0.58	1.57	1.06. 939 295 M.musculus e for anocortin 5 ptor
557	1.74	2.37	1.37	0.96	0.00	0.00	0.026	0.00	1.04	3.07	1.06	0.00	0.00. 352 usculus cadL NA.
304	1.82	1.67	0.75	0.66	0.00	0.00	0.040	0.08	1.25	1.57	1.25	1.36	0.00. 889 304 M. culus (SRP9) al recognition icle subunit NA, 689bp
339	1.68	1.68	1.68	0.00	0.31	0.70	0.003	2.01	1.98	0.00	0.29	0.19	1.30. 382 usculus Six1 NA.
320	1.32	1.81	1.76	0.73	0.00	0.39	0.009	1.15	1.58	0.85	0.51	0.33	1.70. 507 usculus KIS NA.
577	1.23	1.01	0.81	0.48	0.28	0.75	0.049	1.12	1.06	1.33	2.09	0.99	0.93. 685 usculus mRNA K-glypican.
601	1.16	1.37	0.91	0.00	0.20	0.42	0.006	1.21	1.25	1.20	0.22	0.74	1.09. 101 usculus PTX3 NA.

932	1.54	1.19	1.07	0.66	0.34	0.38	0.070	2.12	0.93	1.88	1.12	0.64	0.33	.092	usculus mRNA ryanodine ptor type 1.
368	5.46	35.26	0.09	0.00	0.00	0.00	0.007	0.00	36.57	54.33	0.00	0.00	0.00	.131	usculus putative scription factor.
352	1.19	1.26	1.17	0.10	0.35	0.32	0.000	1.47	1.05	1.24	0.64	0.28	0.95	.053	usculus mRNA Bpx protein.
664	1.32	1.29	1.09	0.82	0.70	0.17	0.033	1.51	1.46	0.91	0.00	0.42	1.10	.103	664 M.musculus NA for ubiquitin- jugating enzyme M2
606	1.33	1.60	1.31	0.00	0.00	0.00	0.000	1.03	1.20	2.07	0.97	0.82	0.00	.131	usculus mRNA Ott protein, clone 7.
719	1.64	1.19	1.15	0.59	0.00	0.66	0.025	1.98	0.98	1.47	0.51	0.00	1.02	.079	719 M.musculus ovirus restriction e Fv1
817	1.16	1.42	1.57	0.55	0.00	0.27	0.005	1.39	1.65	0.96	1.04	0.00	0.18	.071	817 M.musculus NA for aphorin F
581	1.13	0.64	1.18	0.10	0.00	0.14	0.007	1.09	1.15	1.36	0.91	0.00	1.65	.511	581 M.musculus gene encoding ocyte-derived seven smembrane domain receptor, in B6
500	1.36	1.92	1.10	0.94	0.34	0.21	0.044	0.79	1.06	0.63	0.53	1.13	5.00	.379	use glandular ikrein gene.
848	6.67	4.44	5.83	0.00	0.00	0.03	0.001	2.48	0.00	2.96	1.25	0.75	0.00	.310	use int-2 gene.
224	0.91	1.18	1.37	0.00	0.14	0.53	0.011	1.18	1.28	0.97	0.17	1.15	1.03	.330	usculus mRNA 5HT1E beta tonin receptor.
103	0.95	1.40	1.05	0.24	0.19	0.28	0.003	1.07	1.16	1.18	0.54	1.08	0.61	.085	usculus Mox-1 NA.
143	1.19	1.38	1.28	0.15	0.67	0.54	0.007	1.20	1.71	0.93	0.01	0.16	1.07	.099	usculus ALK-6 NA, complete
532	1.23	1.37	1.27	0.00	0.00	0.00	0.000	1.11	1.29	0.65	1.10	0.90	0.00	.418	usculus mRNA follistatin.

166	0.95	1.35	1.34	0.00	0.00	0.26	0.002	1.71	1.51	1.05	2.28	0.00	0.56	.544	166 M.musculus lb/c) mRNA for agen IV alpha 3 in
168	1.00	1.35	1.05	0.05	0.82	0.06	0.041	1.26	1.68	1.00	0.55	1.12	0.77	.128	168 M.musculus NA for collagen lpha 5 chain
147	1.42	1.63	1.08	0.00	0.07	0.00	0.001	0.98	0.66	1.18	1.17	0.04	1.02	.639	147 M.musculus e for cell esion regulator